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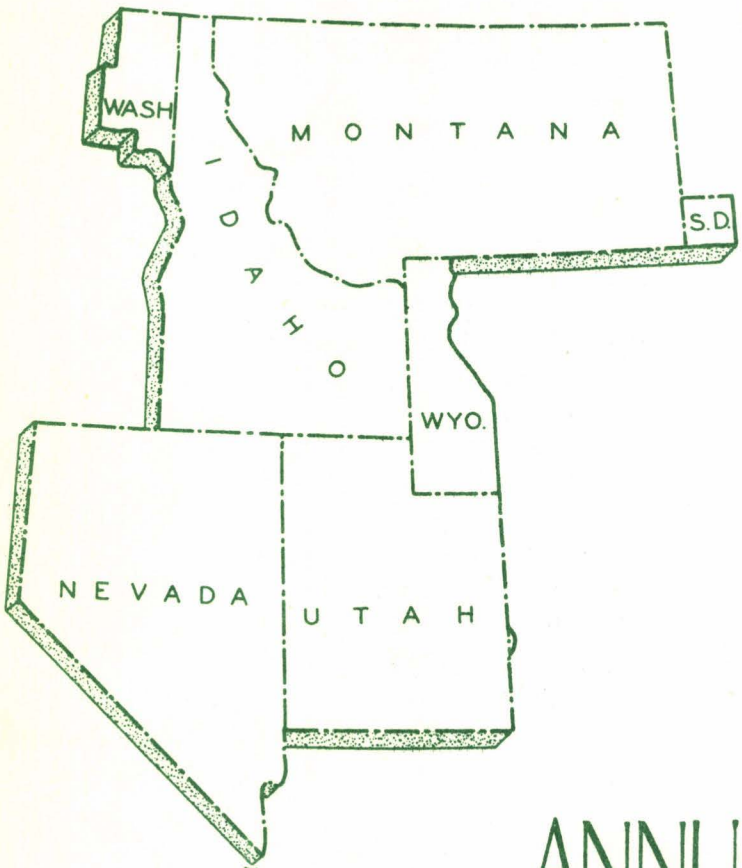

ANNUAL REPORT
1954

INTERMOUNTAIN FOREST & RANGE EXPERIMENT STATION

FOREST SERVICE
U. S. DEPARTMENT OF AGRICULTURE

OGDEN, UTAH

REED W. BAILEY
DIRECTOR

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EXPERIMENT STATION

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A YEAR OF ADJUSTMENT

1954 will be remembered by us of the Intermountain Forest and Range Experiment Station as a year of many changes and personnel shifts. It certainly has been a period of adjustment. Some of the changes have come about as a result of the consolidation of the Northern Rocky Mountain Forest and Range Experiment Station at Missoula, Montana with the Intermountain Forest and Range Experiment Station at Ogden, Utah. Some have resulted from the transfer of forest disease research and forest insect research activities from other bureaus of the Department of Agriculture to the Forest Service. Others have resulted from the transfer of range revegetation and plant control research away from the Forest Service.

The original announcement late in 1953, that these reorganizations would take place, was received with mixed feelings. This was to be expected: each group that was to be combined into this enlarged station had acquired considerable stature in its own field and region. Time alone will tell us the effectiveness of this new combination in comparison with the old arrangement. However, a year of testing and self-inspection permits us to see the probable long-range effects of this reorganization and, in the main, they look good.

These changes have unquestionably resulted in a stronger research organization. Our experience, even in this short time, encourages us to believe that the present program will result over the years in more efficient, better coordinated, and better balanced research. Reorganization has, of course, created certain disadvantages. One of the more obvious is that the enlarged territory of nearly 300 million acres increases the amount of travel to be done by the director and some of the division chiefs. However, disadvantages such as this are more than offset by the increased economy and efficiency of the new setup.

The problems of managing and developing wild lands are both diverse and complex. The benefits from one line of research in this field tend to be limited by the degree of progress in other lines of research. In most cases efficient and economical research calls for the simultaneous, balanced application of several different skills--the team approach. In this respect we gained strength from the acquisition of forest disease and forest insect research. With entomologists and pathologists on the staff, we are in a better position than before to take the team approach to wild land problems. It would be difficult to improve on the fine research done by the old Division of Forest Pathology of the Bureau of Plant Industry, Soils, and Agricultural Engineering, or on the equally fine insect control research by

the Bureau of Entomology and Plant Quarantine. Nevertheless, the addition of these staffs to the station will, I think, be to the advantage of their work as well as the work of other divisions.

The moves of the past year have also served to strengthen us in another way. We now have a better distribution of research personnel in relation to the job to be done than ever before. For instance, we have, for the first time, a research program in Missoula for the purpose of studying the extremely important watershed management problems in the Columbia and Missouri River Basins. Forest management research has been strengthened at Boise. With the employment of a soils expert at Spokane, the attack on the elusive pole blight disease of white pine will be strengthened, and all phases of forest and range research will be advanced as we acquire needed information on forest soils. All in all, the shifts within the station and the additions to the station staff have given a better balanced program than was possible before reorganization.

Experiment stations, like all other organizations, must watch overhead costs. The changes of the past year have helped us in that regard, reducing the proportional load of overhead or administration costs. This means, of course, that a higher percentage of the research dollar is now going into actual on-the-ground research.

The enlargement of the station territory permits us to combine, to best advantage, the local and regional approaches to forest and range research. I believe that in the long run this may prove to be the outstanding gain to come out of the recent reorganization. During the past decade the Forest Service has established many research centers as branches of the experiment stations. This decentralized approach has proved to be a particularly effective mechanism for the type of research we do. Among other things the localization of the experiment station activities has enabled the individual researcher to develop an intimate acquaintance with his own territory and its problems. It has also facilitated the team approach to local problems. These advantages are extremely important.

Consolidation of the two stations permits better coordination--coordination not only to avoid duplication of effort in widely scattered activities, but also to be sure that in the aggregate the research program is well balanced. Many of the forest and range types and problems in the Northern Rocky Mountain Station's territory are similar to those in the territory of the old Intermountain Station. Take ponderosa pine, for example; an important timber species in both regions. The two stations attempted, and largely succeeded, to coordinate their research relating to ponderosa pine. It is apparent, however, that the attack on ponderosa pine problems and on other problems

of broad geographical occurrence is going to be easier to coordinate under the new setup than it was before. For example, we are going to be able to do a better job of relating the forest management activities in the Boise area with those in the territory of the Spokane Center. Range research at the Great Basin Work Center will augment the range studies out of the Missoula Work Center rather than duplicate them. Some of the principles of hydrology relating to forest and range lands developed at the Wasatch and Great Basin Research Centers will apply to watershed problems in Montana and northern Idaho. With intimate knowledge of these principles, research efforts at the Missoula Center in watershed management can operate directly and effectively to the solution of specific local problems.

While coordination and leadership help bring the best out of any organization, the quality of that "best" lies in the capacities of the personnel themselves. Much of my enthusiasm stems from the knowledge that the researchers of the Intermountain Station are of outstanding caliber. That bodes well for the future.

In pointing to the progress, it would be a mistake if I gave the impression that there are no inadequacies in our program. Even when we consider the total research effort being applied to the problems of forest and range lands in our station territory--the work of state agricultural experiment stations, universities and colleges, industry, and all Federal research agencies--and weigh it against the needs, it becomes apparent that in a number of fields present research is not commensurate with the problems. Let me illustrate with two examples.

In realigning our research, I have become very conscious of a need for expanding our economic studies. The Intermountain country has only begun to develop and it has a great future ahead of it. However, in all technical aspects of wild land management--range, watershed, forestry, fire control, disease control, insect control, and utilization--we are plagued with economic problems which, if left unsolved, will hold up progress. These economic aspects need a great deal more attention than we are giving them now.

Another example deserving emphasis is the inadequacy of our research in watershed management. As I said before, we have recently stationed a watershed researcher at Missoula. However, the problems there warrant the attention of more than one man. The Missoula Research Center territory lies at the headwaters of two great river systems. What happens to these headwaters is of vital concern to a large part of the United States. Farther south in the Colorado River country, the states and Federal Government are planning for a multi-billion dollar water development program. Yet the station so far has lacked the resources to tackle the extremely important sedimentation problems in this basin which properly ought to govern management and use of its forest and range resources.

An investigative organization such as ours can pretty well feel the pulse of progress in the questions we are asked. It is significant, therefore, that the tempo of questioning has stepped up considerably in the past several years. We can attribute this situation largely to rapid population growth and increased demand for resources. Though we take great pride in our accomplishments, it is less comforting to measure what we are doing against the great need for information. We plan to devote considerable attention to the matter of developing a research program adequate in all its phases and will have more to say on that score in another year.

The job of organizing for research in such a big diverse, and important country as the northern Rocky Mountain and Intermountain regions has been a real challenge. We have, I think, made encouraging progress. With the staff that is now assembled here, I am confident that we can continue to do so.

REED W. BAILEY
Director

FOREST MANAGEMENT RESEARCH

Forest management may be described simply as the systematized growing of timber as a crop. Research by the Forest Service in this very core of forestry includes nationally six major work projects:

1. Silviculture (basic tree studies, cultural measures in young stands /intermediate cuttings/, and harvest cuttings).

2. Management (application of business methods and technical forestry principles to a forest property).

3. Mensuration (measurement of trees, stands, and products).

4. Forest regeneration (establishing new forests by natural or artificial means).

5. Naval stores (production of resin and turpentine).

6. Forest genetics (improvement of trees and stands by selection and breeding).

The program of the Intermountain Forest and Range Experiment Station now includes investigations in all fields outlined above except naval stores; this work is confined to the southeastern states.

What are the most urgent problems of forest management towards which the Intermountain Station should be directing its research efforts? Primarily, we must learn how to cut for maximum growth, minimum mortality, and prompt regeneration of desired species in the following forest types: ponderosa pine, western white pine (and associated species), western larch-Douglas-fir, lodgepole pine, Engelmann spruce-alpine fir, Jeffrey pine, and aspen. Closely allied to harvest cutting is the problem of artificially regenerating poorly stocked burns and cutover areas. In many cases this involves site preparation of one kind or another. Of considerable urgency, also, is the need to know how to manage extensive second-growth stands of ponderosa pine, white pine, and other commercially important species. Included here are intermediate cuttings.

Underlying the important problems just listed is the need for basic studies designed to increase our silvical knowledge of the tree species of the Intermountain area and provide greater understanding of ecological succession as affected by fire and other disturbances. Also needed are mensurational studies to yield more accurate information on the volume and growth of most of our forest types.

Some of the most perplexing problems facing the forest manager today cut across divisional lines. Serious diseases like pole blight and blister rust of western white pine, and insects such as the bark

beetles, pine butterfly, and spruce budworm call for the coordinated efforts of silviculturists, pathologists, and entomologists. The Intermountain Station is in much better position to provide this concerted attack as a result of the recent reorganization.

During 1954, the first year of consolidation, the Forest Management Research program of Intermountain Station was appraised critically, and its forces were realigned to achieve better balance. This move was aided by a small increase in the funds allotted to the Station for genetics research in the development of a blister rust-resistant western white pine. It permitted an increase from one-half man's time to one and one-half man's time on forest genetics projects.

Improved balance was attained by the following distribution of effort:

Missoula Research Center. Primary research for the Station in western larch-Douglas-fir and lodgepole pine, with minor work in Engelmann spruce-alpine fir. Supplemental research in ponderosa pine.

Inland Empire Research Center. Primary research in western white pine (including genetics) and related species. Supplemental research in ponderosa pine.

Boise Research Center. Primary research in ponderosa pine, the most universal of the commercially valuable trees in the Intermountain area.

With the above organization it is felt that we can go farthest towards solving the problems of the region. While some time was sacrificed during 1954 in personnel moves and reassignments caused by program adjustments, it will be more than offset by future gains. Furthermore, if research in forest management is strengthened in the future, it can be built effectively upon this framework.

Forest Management Research at the Intermountain Station in 1955 will operate along the general lines established in 1954. Greater emphasis will be placed on regeneration by assigning a man from the Division in Ogden to push this important project. He will spearhead investigations in regeneration (natural and artificial) in all types, but with major emphasis at the start on ponderosa pine.

SILVICULTURE AND MANAGEMENT

Ponderosa Pine Production

A concerted effort to complete the installation of the ponderosa pine production study on the Boise Basin Experimental Forest on schedule

continued through the 1954 field season. Because the second replication consisting of 8 compartments totaling 402 acres was designed to include the same combinations of logging methods, marking methods, and levels of reserve volume employed in the first replication, procedures were the same as described in the 1953 Annual Report for that installation.

Other work accomplished prior to logging included the surveying of all spur roads of the first replication to allow revision of experimental forest maps and to permit exclusion of road area from acreage and volume calculations within compartments.

The season's logging operation started early in October. The construction of 2.4 miles of spur roads completed the total of about 7.2 miles of such roads for all compartments. Felling the season's cut of 1.9 million feet was completed in mid-November and skidding was finished in early December. About 500 M bd. ft. have been loaded out and hauling of the remainder is expected early in January 1955.

Slash disposal has been completed for all compartments. Erosion control measures (cross ditching, and road and fill reseeding) have been completed as far as weather conditions have permitted. Because logs still remain in six compartments for winter hauling and because of frozen ground, it is expected that temporary dikes instead of cross ditches will be constructed on roads which are still open. These dikes will be replaced by cross ditches next spring or summer.

Results of this study to date will soon be made available through publications on felling and skidding costs, stand structure, logging damage, saw tree mortality, and sawtimber growth.

Logging Costs in Light Partial Cuts of Ponderosa Pine

Frequent light cuts appear to be economically feasible in ponderosa pine stands, to judge from a logging cost study made in a light experimental cutting. A cut in Lick Creek drainage on the Bitterroot National Forest, removing only 2,260 bd. ft. per acre, cost $24.50 per M bd. ft. log scale loaded on trucks. A total of 500 M bd. ft. of timber was involved in the study. The cost compares favorably with Region One's cost guideline value of $26.63 when the latter is adjusted to a comparable basis of 2,260 bd. ft. cut per acre, 10 logs per M bd. ft., and a moderately easy logging chance. The individual cost elements are compared in table 1. The cost of felling, bucking, and skidding were somewhat higher than regional cost check figures, while the developmental costs were substantially lower.

Table 1.--Comparison of costs per M bd. ft. log scale between Lick Creek light partial cut and regional cost guideline

Elements	Lick Creek	Regional cost guideline
Development: Roads, skidroads, landings	$ 5.38	$ 8.40
Felling and bucking	3.86	2.90
Skidding	8.90	7.08
Supervision, administration, social security, etc.	3.10	4.56
Loading	1.76	2.19
Slash disposal	1.50	1.50
Total	$24.50	$26.63

Mortality Following Partial Cutting of Western White Pine

Mortality during 5 years following partial cutting of a mature western white pine stand was closely related to tree vigor. Residual trees were rated for crown vigor following a 50-percent cutting on Swede Creek in the Clearwater National Forest. Five-year records of mortality are summarized in table 2.

Table 2.--Mortality in relation to vigor class of western white pine 5 years after partial cutting

White pine vigor class	Stand per acre after cutting		5-year mortality		Mortality percentage	
	Trees	Volume	Trees	Volume	Number of trees	Volume
	Number	Bd. ft.	Number	Bd. ft.	Percent	Percent
Good	8.1	7,544	0	0	0	0
Fair	10.5	6,374	0.5	132	4.8	2.1
Poor	4.4	1,715	.9	258	20.5	15.0
All classes	23.0	15,633	1.4	390	6.1	2.5

None of the white pine trees originally rated as having good vigor died. Two percent of the board-foot volume contained in fair vigor trees and 15 percent of the volume in poor vigor trees have been lost to various mortality agents in 5 years. These results agree with those from other tests of partial cuttings in relatively vigorous white pine stands on the Coeur d'Alene and Kaniksu National Forests. They again

point up the possibilities of selection on a vigor basis in partial cutting of mature western white pine.

Ribes Control Tests

A portion of the Deception Creek Experimental Forest is being devoted to tests of ribes control in cooperation with the Division of Blister Rust Control. Three units are involved in the study:

1. A clear-cut unit on a north-facing slope on which the ribes were sprayed with 2,4,5-T in 1954. Western white pine trees will be planted after eradication of ribes. Part of the unit will be planted to trees produced by the blister rust-resistant white pine breeding project.

2. A seed-tree unit on which an unmerchantable western hemlock understory was felled and the slash piled. It is expected that this unit will reseed naturally to white pine after ribes control by broadcast spraying with 2,4,5-T.

3. Another clear-cut unit similar in treatment to (1.) above to be established on a south-facing slope.

Installation of the study will be completed within the next 2 or 3 years.

Effect of Understory Trees Upon Diameter Growth of Residual Larch

On the Coram Experimental Forest in mature and overmature western larch, release from initial reproduction cuttings increase postlogging diameter growth of the residual trees 67 percent over prelogging growth in the first 5-year period. A further increase of 2 percent was noted in the second 5-year period. Even more significiant is an additional increase of 36 percent which resulted from the removal of undesirable species from the understory. These increases brought average diameter growth to 0.62 inch per decade in the second 5-year period following cutting as compared to 0.30 inch per decade before cutting.

Treatments in this study included no treatment (control), mechanical scarification, broadcast burn after slashing small trees, and understory slashed and burned in piles.

The data help to point out a strong reason why response of larch to logging release is poor. Larch stands are usually succeeded by more tolerant species, such as Douglas-fir, alpine fir, western hemlock, and western redcedar. These understory trees limit the growth response of overwood larch through competition for available soil

moisture. Where the understory trees are thinned by bulldozer in seedbed preparation, some release is also given the overstory trees supplemental to this work.

Tree Vigor and Douglas-Fir Beetle Attacks

A study of the relation between tree vigor in Douglas-fir and attack by the Douglas-fir beetle indicates that low-vigor trees are most susceptible to attack under endemic conditions, but that under epidemic conditions high-vigor trees may be equally susceptible. A total of 186 beetle-infested trees and 920 adjacent uninfested trees on the Kaniksu, Coeur d'Alene, St. Joe, and Clearwater National Forests were observed and classified according to tree vigor. Region One of National Forest Administration cooperated in the project.

Susceptibility indexes were calculated using the following formula:

$$\text{Susceptibility index} = \frac{\text{Percentage of infested trees in given vigor class}}{\text{Percentage of given vigor class trees in stand}}$$

The resulting values by tree vigor class for each of the four national forests are given in table 3. Stands studied on the Kaniksu

Table 3.--Susceptibility index by tree vigor and intensity of infestation

National forest	Tree vigor class		
	Good	Fair	Poor
Endemic infestations			
Kaniksu	0.091	0.805	2.462
Clearwater	.462	.621	1.310
Epidemic infestations			
Coeur d'Alene	1.333	.884	1.000
St. Joe	1.733	.739	1.026

and Clearwater National Forests contained relatively light beetle infestations. Susceptibility indexes for these forests show a parallel relation to tree vigor. In stands studied on the Coeur d'Alene and St. Joe National Forests, infestation by the Douglas-fir beetle was in an epidemic stage. Here the susceptibility indexes showed little relation to tree vigor.

Results from this limited study suggest that Douglas-fir beetle infestations build up in the low vigor trees of the stand and then, when large numbers of beetles are present, all vigor classes are likely to be attacked.

Lodgepole Pine Research in the Intermountain Region

During the years 1952 to 1954, inclusive, the Intermountain Station through the cooperation of Region Four of the Forest Service carried on a study of the status of lodgepole pine management in the Intermountain area. It culminated this past year in a comprehensive problem analysis of the species which was released as Miscellaneous Publication No. 2 by the Intermountain Station in June. In addition to a discussion of the problems of management and a suggested list of needed research studies, the analysis includes a preliminary lodgepole pine stand classification which should be useful to forest managers concerned with this type. A separate writeup of the classification will be published soon in the Journal of Forestry.

As a result of the problem analysis on lodgepole pine in Region 4, a study was made of the viability of lodgepole pine seed retained in cones in slash and effects of cone position. Unopened cones were collected from 6-year-old logging slash on the ground and as much as 3 feet above ground.

Germination tests with extracted seed showed that (1) some seed stored in unopened cones in logging slash remain viable for at least 6 years, and (2) seed from cones above ground in this study had twice as much germinative capacity and germinative energy as seed from cones on the ground. (Germinative capacity is defined as percentage of germinable seed in a sample, and germinative energy as percentage of germination obtained in a definite period of time.) These findings give assurance that seed in logging slash can help regenerate clear-cut lodgepole pine lands for 6 years or more. It is apparent, also that the slash disposal method employed can influence the viability of seed available for regeneration.

The forester assigned to the cooperative project is now stationed at the Missoula Research Center from where he will continue investigations in lodgepole pine in the Intermountain area.

MENSURATION

Growth of Young Ponderosa Pine Stands

Stands of second-growth ponderosa pine are reaching the lower limits of merchantability in many parts of the West. To manage these young stands wisely, foresters and land owners need reliable information on their growth capacities.

A research paper containing growth tables for young ponderosa pine trees was published this year. The tables show predicted 10-year cubic-foot-volume growth for individual trees by age and diameter class. Applied to a stand table for any particular forest property, they will give accurate gross growth predictions for the next decade.

Mortality adjusting factors are also included which permit the prediction of net cubic-foot-volume growth. Converting factors for changing cubic-foot volume to board-foot volume and to cordwood volume are also included.

Allowable Errors in Sample Scaling

With increased interest in the use of sampling methods for volume determination in national forest timber sales, the problem of accuracy standards becomes increasingly important. Just what is a reasonable allowable error in sample scaling commensurate with timber values and scaling costs?

Because sampling errors are not reduced in direct proportion to increased sampling intensities, there is a point of diminishing returns in sampling where the increased cost of a more intensive sample is not justified by the reduction in sampling error.

A research note published this year will help to answer this question of acceptable sampling errors in sample log scaling and tree measuring. A graph alinement chart in the publication gives the most economical allowable errors for a range of total sale values, variability of volumes, and scaling costs.

Delineating Ponderosa Pine Volume and Site Quality Classes from Aerial Photographs

The installation of the experiment in ponderosa pine management at Boise Basin Experimental Forest required the delineation of 3 volume-per-acre classes of timber on the ground in each of 16 compartments totaling 847 acres. Interpretation of aerial photographs saved considerable time and effort in completing the delineation.

Subsequent 100-percent cruises of each class checked the accuracy of delineation and afforded material for a series of stereograms for volume classes between 9 and 35 M bd. ft. per acre. Suggestions for the use of stereograms in improving timberland sampling are given in a publication covering the work.

REGENERATION

Effect Upon Seed Production of Size of Larch Seed Trees

In a study on the Coram Experimental Forest 4-year seed production of scattered western larch seed trees was found to vary significantly with average size of the trees. The study was made in a seed-tree cutting in which 4 to 5 dominant mature western larch trees with well-developed crowns were reserved for seed production. A few additional trees were left to bolster up future cuts, and some were left

because they were too small to log. Seed fall was measured with conventional 1/4 milacre seed traps placed in the center of 1/5 acre plots installed to collect data on the overwood. The seed catch for a 4-year period, including the excellent crop in 1952, showed a highly significant correlation with average d.b.h. of the seed trees on each plot.

Average d.b.h. of seed trees Inches	Average seed production per tree Number
14	19,700
18	59,700
22	99,500

The seed fall from trees under 12.5 inches d.b.h. was negligible, and trees below this size should not be considered as an effective seed source. No trees above the 22-inch class were included in the study but it is likely that seed production would level off or even decrease in trees above this size. Such trees are generally decadent and have small crowns.

Seedbed Preparation for Natural Regeneration of Western Larch

That ground preparation favors natural regeneration of western larch over less desirable associated species has been substantiated by the following experiment. During the period 1943 to 1945, an extensive area of larch-Douglas-fir timber was logged in a commercial seed-tree cutting on the Coram Experimental Forest. The stand before logging was mainly mature and overmature larch, Douglas-fir, and Engelmann spruce, with minor quantities of white pine, lodgepole pine, and alpine fir. The objective was to harvest most of the crop, but reserve a small residual of 4 to 5 dominant larch trees per acre as a seed source for natural regeneration. No seedbed preparation except that incidental to logging was carried out. In 1949, it was decided to determine whether or not stocking of western larch and Engelmann spruce could be increased by various methods of seedbed preparation. The following treatments were employed:

1. No treatment (control).

2. Mechanical scarification. The ground was sacrified with a tractor-drawn Athens disk or a brush blade on the tractor.

3. Broadcast burn. Small residual trees and shrubs were slashed to provide fuel for a broadcast burn.

4. Understory slashed, piled, and burned. The understory of undesired trees and shrubs was slashed and burned in small

piles. Little additional mineral soil was exposed by this treatment, but the stand was opened to light and moisture.

Results of the treatments for the three principal species in the stand are presented in table 4.

Table 4.--Percent of milacre quadrats stocked with western larch (WL), Engelmann spruce (ES), and Douglas-fir (DF) before and after three ground treatments were applied

Treatment	Stocking before treatment (1949)			Total stocking, 1953			Net increase since treatment		
	WL	ES	DF	WL	ES	DF	WL	ES	DF
Control	28	21	48	37	27	56	9	6	8
Mechanical scarification	17	8	38	54	20	57	37	12	19
Prescribed burning	27	18	40	65	40	59	38	22	19
Slashing understory	32	13	49	42	16	55	10	3	6

In terms of net increase in stocking all species were favored by the increased exposure of mineral soil resulting from the mechanical scarification and prescribed burning. However, western larch benefited more than Douglas-fir and Engelmann spruce from these two treatments, and so gained a more favorable position with regard to its competitors.

Seedbed Preparation in Engelmann Spruce-Western White Pine

Effectiveness of methods of seedbed preparation are being tested in clear-cut blocks in the Engelmann spruce-western white pine type on the St. Joe National Forest. Personnel of the St. Joe National Forest, Potlatch Forests, Inc., the University of Idaho, and the Station cooperated in the installation of the test to compare the effectiveness of three intensities of dozer piling of logging slash with prescribed broadcast burning and with untreated areas as seedbed preparation in obtaining natural reproduction. Slash, ground surface, and plant cover were inventoried on each of 10 test plots. All treatments were completed in 1954. A heavy Engelmann spruce seed crop this past fall should give the test an excellent start.

Viability of Ponderosa Pine Seed as Affected by Origin and Storage

An analysis of germination data secured in 1950 revealed that storage method, and to a lesser extent age and altitudinal location

of parent trees, affects the germinative capacity of central Idaho ponderosa pine seed in dry storage. After 14 years, seed from young (50-70 years) open grown trees at 5,500 feet and stored at 32° F. had the highest value (74.7 percent) and seed from scattered old growth trees at the same altitude in above ground cellar had the lowest (44.7 percent). Interaction of variables was also evidenced by differences in germinative capacity for a particular origin depending on the storage method.

Banding Ponderosa Pine Seed Trees to Keep Out Squirrels

It appears more and more likely that keeping squirrels out of selected trees in partially cut ponderosa pine stands will increase seed fall appreciably. In the summer of 1953 a small-scale test of banding tree trunks as a means of controlling squirrel damage to seed crops was installed at Dunn Creek on land owned by the J. Neils Lumber Company, Libby, Montana. Five isolated seed-bearing trees per acre were selected on 11 acres and protected by attaching a 20-inch-wide metal band to the trunks at from 5 to 7 feet above the ground. A check of cone cutting on protected and unprotected trees showed that the bands were effective in keeping squirrels out of the trees.

Because protection against squirrels gives promise of increased seedfall, efforts are now being directed towards refining the techniques of tree banding.

A Poor Ponderosa Pine Seed Crop is Forecast for 1955

This prediction is based partly on data obtained in a ponderosa pine seed-crop forecasting study on the Kootenai National Forest. Examination of about 100 permanently tagged branches on 8 trees disclosed that not more than 2 cones will mature on the sample branches next fall, as compared with from 80 to 144 cones maturing on the same branches in moderately fair seed crops in the past. Casual observations on trees in the Lolo and Bitterroot National Forests point to a poor crop for 1955 in these areas also.

Regeneration of Lodgepole Pine in Clear Cuttings

The relations of seed supply, logging, and slash disposal methods to natural regeneration in lodgepole pine clear cuttings has been clarified in 5 years of study in Montana. The principal seed supply on such cuttings is contained in the persistent cones borne on the logging slash scattered on the ground by logging activities, or has been dispersed from standing trees before cutting.

The Montana studies show that few seed are dispersed beyond distances of about 2½ tree heights from the uncut bordering timber. Side seeding is effective, then, only on a fringe strip containing one-half or less of the area in the 30- to 50-acre clear-cut blocks.

Burning of all slash destroys considerable quantities of the seed and poorly stocked seedling stands result on the burned-over seedbed. Likewise, sparse stands of new seedlings develop initially on seedbeds covered by windrows of slash, but additional seedlings gradually fill in the unstocked ground. On scarified seedbed, seedlings become established abundantly and quickly. The seedlings are distributed well enough to provide a uniform forest stand, but the large number of seedlings per acre presents another problem--that of possible future overstocking.

Fire hazard reduction has been considered in connection with the slash disposal methods. Burning of windrowed and bunched slash as well as bulldozer piling of slash immediately reduced the fire hazard to an acceptable level. Where no slash disposal has been practiced or slash has been lopped and scattered, fuel ratings continue to be higher than an acceptable level 5 years after treatment.

A Small Seed Trap

The Station has developed a 1-foot-square wire seed trap useful in seed dispersal studies. The trap is simple to construct and costs only about one-fourth as much as the conventional 1/4-milacre traps. The small trap is light in weight and can be transported and placed with ease. It has been tested by two seasons of use and has withstood successfully the pressure of snow depths up to 4 feet. Results from 21 1-foot-square wire traps compared with 17 quarter-milacre traps gave almost identical estimates of the mean for the 1952 western larch seed crop with only a slightly greater sampling error in the smaller traps. The trap and its method of construction are described more fully in a manuscript submitted to the Journal of Forestry.

GENETICS

Breeding Blister Rust-Resistant Western White Pines of Good Growth and Quality

For the fifth consecutive year the Station has cooperated with the Spokane Unit, Blister Rust Control, National Forest Administration, and other organizations in breeding blister rust-resistant and otherwise superior western white pines. This project has grown to major proportions, with large numbers of progenies and grafted trees produced from apparently resistant selections now under test. Early results appear promising, both in developing resistance and in improving other traits. A publication issued this year summarized techniques and early results in breeding for faster growth rate and better timber quality. Another manuscript, "Self-compatibility and effects of self-fertility in western white pine" by R. T. Bingham and A. E. Squillace, was submitted to the Journal of Forestry for publication.

As in the past the Station provided assistance in controlled pollination, growing and outplanting of progenies for resistance testing, grafting, and examination of progenies and grafted trees for symptoms of rust. Intensive measurements of growth rate and branching habit among progenies and grafted trees were continued. Some new developments, mainly concerned with breeding for vigor and quality are listed below:

1. A selective fertilization study was begun, designed to determine the extent of self-fertilization that will occur when pollen from the same tree competes with pollen of other trees of the same species. Results of this work may be important in seed orchard planning.

2. Three 10-acre plots were cleared and prepared for outplanting progeny (seedlings) for long-term study of the inheritance of vigor and timber quality. The plots are located in rust-controlled areas at Emerald Creek (St. Joe National Forest), Deception Creek Experimental Forest, and Priest River Experimental Forest. Progenies of selected crosses will be outplanted in these plots at a spacing of 8 x 8 ft. The first planting will consist of progenies (2-1 stock) from 54 cross-, self-, and wind-pollinations, to be set out in the spring of 1955. Three similar outplantings are planned for succeeding years.

3. Two small tests were installed specifically to study variation in seed weight, its effect upon first-year seedling heights, and adjustment techniques. Results are now being analyzed.

Field Tests of Hybrids

Early growth and crown form of lodgepole pine x jack pine hybrids produced at the Institute of Forest Genetics (Placerville, California) compare favorably with local lodgepole pines used as controls. The oldest trees are now 7 years from seed. In two of the three outplanting sites, the hybrids averaged 37 percent taller and 15 percent larger in diameter than local trees; in the third site they were about the same. Considerable variation in crown width relative to total height occurred among planting sites, but on the average the hybrids were slightly narrower crowned. At all sites the hybrids had fewer branches per whorl.

Seed Produced Following Controlled Pollination

Controlled pollinations made on local trees in the spring of 1953 were variable in production of sound seed. Comparative yields were as follows:

Species	Seed yields
Pinus ponderosa x P. ponderosa v. scopulorum	Good
P. ponderosa x P. engelmannii (apacheca)	Poor
P. ponderosa x P. ponderosa v. arizonica	Very poor
P. ponderosa x P. montezumae	None
P. contorta x P. banksiana	Fair to poor

One intraspecies cross and one self-pollination in ponderosa pine yielded good and fair numbers of sound seed, respectively.

OTHER

The Division assisted Timber Management of Region Four, National Forest Administration, in the design of a 138-acre spring planting trial near Idaho City on the Boise National Forest where some 65,000 acres of fine timberland are unproductive as a result of past uncontrolled fires. Variables of ground preparation and ponderosa pine stock were employed in combination, with allowances made for additional variables of competition and aspect if desired.

First-year results are encouraging although favorable weather may have played a deciding role. Statistical analyses of year-end survival indicates highly significant differences between the variables employed and interaction between them. It is planned to continue these plantings for at least 4 more years.

The Intermountain Station served as host for a meeting at Boise, Idaho, of personnel engaged in ponderosa pine research at the western forest and range experiment stations. Timber management divisions from the western regions of National Forest Administration were also represented. All phases of management were discussed. This conference should be most effective in coordinating research effort throughout the range of ponderosa pine.

RANGE MANAGEMENT RESEARCH

When last year's annual report was being written, most of the range research formerly carried on by this Station in artificial revegetation and in noxious plant control was in process of being transferred to the Agricultural Research Service. The year has seen these changes effected. This work is now being carried on under the able field supervision of Mr. A. C. Hull of Agricultural Research Service, whose extensive experience in range research in Utah, Nevada, Idaho, Wyoming, and Colorado was gained as a former member of the staffs of both the Intermountain and Rocky Mountain Forest and Range Experiment Stations. Mr. Hull's familiarity with western range problems insures that the research in his unit will be effectively directed.

A major effort in the Division of Range Research has been to complete manuscripts in artificial revegetation and plant control that were in process of preparation or were ready to be undertaken at the time of reorganization. These include one on seeding rangelands in the Intermountain area for an Agricultural Handbook by Plummer et al.; one on species adaptability and seeding season in northeastern Washington for a Station research paper by Evanko; and two manuscripts, one on seeding rates for crested wheatgrass, and one on the effects of 2,4-D on species associated with big sagebrush, for the JOURNAL OF RANGE MANAGEMENT by Blaisdell and Mueggler. In addition, USDA Farmers' Bulletin 2072, "Controlling Sagebrush on Range Lands," and a revised edition of Farmers' Bulletin 1948, "Sagebrush Burning--Good and Bad," by Pechanec et al., were published in 1954.

In order to bring up to date and make available results of artificial revegetation research that this Station has carried on in southern Idaho, Mr. Hull is collaborating with Ralph C. Holmgren of the Boise Research Center, and with the University of Idaho, in making a final reexamination of field trials of species adaptability and methods in artificial revegetation. A preliminary survey was made in the fall of 1954, and it is expected to complete the field work on this joint project during the summer of 1955.

NATIVE SUMMER RANGE

Cattle Gains

For the past several years, the Vigilante Experimental Range in the upper Ruby River Valley of southwestern Montana has been conservatively stocked with cattle for approximately 5 months, June through October. Fairly uniform grazing has been secured by the naturally well-distributed water supply, supplemented by a good salting program and considerable riding.

Gains made by cattle on this summer range have compared favorably with gains made on cultivated pastures and even in feedlots. Steers, heifers, and dry cows have made average gains of between 2 and 3 pounds per day from early June until late September when they were removed from the range and sold as beef. Records for the entire 5-month grazing season are available for only a few animals, but these indicate that the same rate of gain did not continue through October.

Current cattle weights followed a pattern similar to that of past years. During the first 108 days (6/12-9/27), yearling steers and heifers on the Vigilante range gained an average of 2.5 and 2.2 pounds per day, respectively. For the entire grazing season of 138 days (6/12-10/27), however, steers averaged 1.8 pounds per day and heifers 1.6. Apparently good gains can be expected while the forage is green and succulent, but after it is mostly dried, weight losses occur, or at best rate of gain is greatly retarded.

Salt Consumption by Cattle

Average salt consumption during the 138-day grazing season per head of mixed cattle (calves excluded) was 4.69 pounds. Use by months was as follows:

Month	Pounds per head
June (19 days)	0.29
July	.79
August	1.59
September	1.14
October (27 days)	.88
	4.69

Contrary to general belief, the demand for salt appears to be considerably greater during late summer and fall than in spring and early summer. Because of changes in herd composition September 27, the apparent reduction in amount used during October may not be significant. A similar pattern of use in the past 6 years, however, indicates that salt consumption is actually light during the early part of the grazing season, heavy during the middle part, and intermediate during the latter part. During the past season approximately 20 percent of the block salt was lost through weathering.

Response of Forbs to Clipping

Generally speaking, proper use for a forage species is the degree of use which allows that species to produce the maximum amount of herbage consistent with the maintenance of sufficient vigor and ground cover to insure soil stability. It would be a great help to the range manger if he had a reasonable approximation of proper use, a rough guide, that he could apply to key species. Such guides have

been established for some grasses and a few browse species, but we know little about the reaction of forbs to different degrees of utilization. This is surprising in view of the fact that forbs provide a large portion of the forage on summer ranges.

In an attempt to add to our knowledge of proper use a study was initiated in the summer of 1950 which included the clipping of five species of forbs, Valeriana edulis, Geranium richardsonii, Ligusticum porteri, Castilleja linariaefolia (red castilleja), and C. sulphurea (yellow castilleja). Groups of 6 of these plants were clipped in the flowering stage each year for 4 years at intensities of 50, 75, and 90 percent of current growth, and an unclipped group in each species was included for comparison. In the case of the castillejas growth was measured and removal accomplished in terms of inches, whereas green weight in grams was used for the other three species. The initial differences between treatment groups were adjusted by covariance analysis.

Only two of the five species, valerian and geranium, showed differences between adjusted mean weights or lengths that could be attributed to treatment (table 5). Both valerian and geranium

Table 5.--Adjusted herbage production of forbs as affected by clipping, together with variance ratios (F) and least significant differences, 1954

Species	Treatment				(F)	Least significant differences	
	Unclipped	50% clipped	75% clipped	90% clipped		0.05	0.01
Valerian (gm.)	124	97	55	39	1/ 8.37	40	54
Geranium (gm.)	156	103	63	42	1/ 5.05	65	89
Ligusticum (gm.)	124	161	124	106	.62	--	--
Red castilleja (ins.)	46	82	70	31	1.97	--	--
Yellow castilleja (ins.)	90	51	58	72	.58	--	--

1/ Highly significant

showed a graduated response to treatment and highly significant differences between the 75 percent clip and the unclipped, and between the 90 percent clip and the unclipped. In addition, in the case of valerian, the differences between the 50 and 90 percent clip and the 50 and 75 percent clip proved to be highly significant and significant, respectively. In neither instance was the difference between the 50 percent clip and the unclipped large enough to be significant.

It is apparent from table 5 that utilization of valerian and geranium resulting in removal of three-fourths or more of the current growth will cause a substantial reduction in herbage produced. It is also probable that removal of half the current growth of these two species each year for several years will reduce their production of herbage, although for the 4-year period covered by this study the effects are not statistically significant. On the basis of these findings it may be concluded that proper use of valerian and geranium is approximately 50 percent or less. Even 50 percent use during the bloom each year may be detrimental over a period of many years.

There was no graduated response to treatment with ligusticum and the castillejas. Although there is a suggestion of stimulated growth from some treatments, none of the differences found were significant. For effects of treatment to be discernible in these species the study would have to be carried on over a longer period or larger numbers of plants would have to be used.

SEEDED SPRING-FALL RANGE

Cattle Gains

Following tests to find species adapted for range seeding in northeastern Washington, five 6-acre pastures were fenced from an area of abandoned marginal cropland on the Bremner Ranch, near Republic, and four were seeded, each to a different species, in the spring of 1952. Now herbage production of intermediate wheatgrass, crested wheatgrass, pubescent wheatgrass, and smooth brome are being compared with production of weedy species on the adjacent untreated pasture.

Grazed for the first time in 1954, the seeded species have shown their superiority in providing early spring forage. Despite unfavorable growing conditions, intermediate wheatgrass, crested wheatgrass, pubescent wheatgrass, and smooth brome leafage averaged 4.9, 4.0, 4.0, and 4.3 inches in height, respectively, on May 2 when the pastures were stocked, compared with 1.0 inch for cheatgrass on the untreated area. Early growth and a large volume of forage are of most importance to the operator during the spring between winter feeding and the opening date for grazing on national-forest summer ranges.

Results of the 1954 test are shown in table 6. Intermediate wheatgrass, which developed most rapidly and provided most forage, furnished the greatest number of animal-days' use. Crested wheatgrass ranked second. Pubescent wheatgrass ranked third chiefly because in this test a spotty stand was obtained. Despite this poor stand, herbage production of pubescent compared favorably with that of crested, suggesting that it would have ranked ahead of crested wheatgrass if a good stand had been obtained. Of the species seeded, smooth brome was considered least desirable because of its relatively low productivity early in the season.

Table 6.--Animal days of use, animal gains, and herbage production on seeded pastures, Bremner Ranch, 1954

Pasture	Cow-calf use	Total gains		Herbage production		
		Cows	Calves	Through grazing period	After grazing period	Total
	Days	Pounds		Pounds		
Intermediate wheatgrass	144	560	240	1,454	1,047	2,501
Crested wheatgrass	96	420	170	771	932	1,703
Pubescent wheatgrass	78	390	145	538	1,059	1,597
Smooth brome	78	195	125	489	1,162	1,651
Unseeded (Cheatgrass	--	--	--	63	248	311
(Forbs				264	322	586

Production of cheatgrass and forbs was both low and late. Cheatgrass produced less herbage over the entire season than smooth brome produced during the early spring period. This small amount of herbage precluded stocking the control pasture this year. Although cheatgrass provides good livestock forage under favorable conditions, it is difficult to manage a livestock operation on this basis.

The Bremner pastures corroborate results from elsewhere that seeding early spring and fall ranges now in cheatgrass to adapted perennial species will help stabilize the livestock operation and also result in greater yields of livestock products.

Palatability of Seeded Grasses

In 1950 grazing was started at the U. S. Sheep Experiment Station, Dubois, Idaho, on a study designed to provide information on the palatability to sheep of 10 grass species. Three of these are wheatgrasses native to this country--bluebunch, bluestem, and thickspike wheatgrass--and the remaining 7 are popular introduced species--intermediate, pubescent, Fairway crested, standard crested, Siberian, and tall wheatgrass, and Russian wildrye. These grasses were planted in replicated plots on a silt loam soil of basaltic origin in the 11-inch precipitation zone. Good stands were obtained of all species before the grazing treatment began, with the exception of native bluebunch wheatgrass which produced no better than a fair stand.

Table 7 gives the 4-year average of annual production by species. It is interesting that of the native species only bluestem wheatgrass has shown the degree of productivity achieved by some of the introduced wheatgrasses. (The low productivity shown for bluebunch wheatgrass, however, is partly a result of the fact, already noted, that a good stand of this species was not obtained.) These production figures differ in some respects from results on spring-fall

Table 7.--Average annual production and spring utilization by sheep, in pounds per acre, air-dry, of 10 grasses, together with least significant differences for utilization

Species	Total production		Spring utilization
Intermediate wheatgrass	902		180
Pubescent wheatgrass	957		152
Fairway crested wheatgrass	858		107
Standard crested wheatgrass	921		105
Russian wildrye	649		101
Siberian wheatgrass	855		87
Tall wheatgrass	622		52
Bluestem wheatgrass	928		34
Thickspike wheatgrass	510		30
Bluebunch wheatgrass	380		13
		LSD(t.01)	68
		LSD(t.05)	50

range in central Utah (1951 Annual Report, page 28), which suggests both the possibility of strain differences and the importance of a better understanding of why the same kind of plant reacts differently in slightly different sites.

A comparison of utilization for the years 1951 through 1954 reveals significant differences in amounts of forage removed in the spring. Since the sheep had free access to all species and the amount of forage available during the grazing period was seldom a limiting factor, the amounts removed are considered indicative of relative palatability. Table 7 presents the amounts of forage utilized in the spring by sheep, and the least significant differences for these figures at the 95- and 99-percent levels (t.05 and t.01, respectively).

The differences in palatability between species are not all significant even at the 95-percent level. Significantly more herbage was removed from intermediate wheatgrass than from any other species except pubescent wheatgrass, and more from pubescent wheatgrass than from any of the others except intermediate and the crested wheatgrasses. Significantly more forage was removed from Fairway and standard crested wheatgrass than from tall, bluestem, thickspike, or bluebunch wheatgrass. As a matter of fact, all the introduced species, with the exception of tall wheatgrass, were grazed significantly heavier than the native wheatgrasses. At the Vigilante Experimental Range a similar study also shows that introduced grasses are more palatable than native grasses to cattle. (Schmautz, Jack E. Grass--cafeteria style in southwestern Montana. Research Note 12, 4 pp., 1954.)

Detailed utilization determinations were not made after fall grazing, but general observations indicated a conspicuous change in preference rating of Russian wildrye. In spring this species was only moderately palatable compared with the other species, but in fall it was generally preferred by the sheep.

Changes in Vegetation under Grazing

Benmore, Utah

This is the seventh consecutive year in which 12 grazing treatments have been applied to the 24 100-acre pastures at Benmore. A survey of the vegetation in 1954 showed some interesting differences developing in crested wheatgrass among the three intensities of grazing (table 8).

Table 8.--Response of crested wheatgrass at Benmore to three intensities of spring grazing

Intensity	Plants per 10 sq. ft.		Basal area of crested wheatgrass, percent	"Wolf" plants per 100 sq. ft.
	Total	Small1/		
Light	18.4	0.89	0.14	3.6
Moderate	18.6	.73	.12	1.8
Heavy	15.4	.57	.09	.1

1/ Plants of less than 1 inch crown diameter

That fewest grass plants are found in the heavily grazed pastures reflects the fact, to some extent, that fewest plants were there at the outset of the experiment. But grass plants have not been increasing in number so rapidly on the heavily grazed pastures as on the others. Since 1951 the increase has amounted to 9.3 percent in the lightly, 5.3 percent in the moderately, and only 0.4 percent in the heavily grazed pastures. Small, presumably young plants were materially more numerous in the lightly than in the heavily grazed pastures in 1954.

The proportions of the ground surface occupied by the bases of living shoots (basal area) show a similar differential. An important contributing factor here is the difference in numbers of plants with dead centers: 24 percent in the lightly, 30 percent in the moderately, and 43 percent in the heavily grazed pastures. Basal area, like numbers of plants, was lowest in the heavily grazed pastures at the beginning of the study. Since 1951 basal area has increased 4.9 and 2.5 percent in the lightly and moderately grazed pastures, respectively, but only 1.4 percent in the heavily grazed pastures.

The numbers of "wolf" plants (ungrazed plants in which old growth accumulates) have decreased in both lightly and moderately grazed pastures during the past 2 years, principally because of poorer-than-average growth conditions. The numbers of these plants fluctuate from year to year, depending upon the amount of forage produced, but the ratio between intensities remains pretty much the same. "Wolf" plants in heavily grazed pastures are found only where protected by brush.

Rubber rabbitbrush and big sagebrush are increasing in all pastures, and the increase is influenced by intensity of grazing. Table 9 shows the numbers of brush plants in 1954 by intensity of use.

Table 9.--Numbers of brush plants per 100 sq. ft. under three intensities of grazing at Benmore

Intensity	Rubber rabbitbrush		Big sagebrush	
	Total	Small[1/]	Total	Small[1/]
Light	6.5	3.4	1.8	1.0
Moderate	6.0	2.9	2.7	2.0
Heavy	7.5	4.8	12.1	9.7

1/ Plants less than 4 inches tall

The tendency for both rabbitbrush and sagebrush to be most abundant on the heavily grazed pastures is evident, and the greater abundance of small--presumably young--plants there suggests that the difference will become greater as the years pass. Since 1952 numbers of the larger rabbitbrush plants have increased on all pastures--1.1 percent on the lightly, 24.0 percent on the moderately, and 13.3 percent on the heavily grazed pastures. For sagebrush the corresponding increases have been 27.8, 63.7, and 83.6 percent.

Ruby Valley, Nevada

In 1944 a cooperative agreement was developed between private ranchers, Bureau of Land Management, Humboldt National Forest, and Intermountain Forest and Range Experiment Station whereby 825 acres near Arthur in northeastern Nevada were cleared of big sagebrush, fenced, and seeded to crested wheatgrass. For the past 8 years approximately 400 head of cattle have entered the area on the date when, otherwise, they would have entered the Humboldt National Forest, usually around May 20. At this time crested wheatgrass has made most of its growth. The animals remain about 3 weeks. This area has furnished an equivalent of 272 animal-months' grazing each spring--or 1 animal month on each 3 acres.

This area was estimated to provide only 15 to 20 animal-months' grazing prior to treatment, so that grazing capacity has been increased some 15 to 20 times by eradicating brush and seeding to crested wheatgrass. Had adequate water been available, permitting better distribution of cattle, it is estimated that an additional 50 to 60 animal-months' grazing could have been obtained each spring without damage to the grass. This study area has provided an effective demonstration of how an almost worthless tract could be made productive, lessening grazing pressure on higher watershed lands.

Following seeding, cross fences were built, dividing the 2½-mile-long area into 3 pastures of 250, 400, and 175 acres, from north to south, respectively. A plan to graze each pasture at a different intensity was abandoned when water shortages developed and it was necessary to leave gates open between pastures. However, a differential in use developed naturally among the 3 pastures as a result of differences in availability of water. Over the years the south pasture has been grazed most heavily and the north pasture most lightly. There has been a tendency, also, for the western ends of all pastures to be grazed more heavily than other parts.

A survey of the vegetation was made in 1954 in cooperation with Mr. Alvin T. Bleak, formerly of this Station and now with the ARS in Reno. In this survey, effects of the different intensities of use were reflected in the vigor of crested wheatgrass, as shown by differences in numbers of plants with dead centers. In the south pasture 35 percent, in the middle pasture 29 percent, and in the north pasture 23 percent of the crested wheatgrass plants had dead centers. Evidence of the difference in use is given by the numbers of "wolf" plants. These average 4.9 per 100 square feet in the south pasture, 7.9 in the middle, and 12.9 in the north.

Trends in sagebrush were determined by counting annual growth rings and dividing the bushes into age classes accordingly. In table 10 the results are shown, together with those from counts of old plants and seedlings prior to treatment and in 1947.

Table 10.--Numbers of big sagebrush per 100 sq. ft. on Ruby Valley pastures

Age of plants, years	Prior to treatment	1947	1954
Over 10	19.1	3.9	1.3
9 - 10	--	--	4.7
3 - 8	--	--	.1
Less than 3	71.0	6.9	1.5
Total	--	--	7.6

The old plants were reduced about 80 percent by eradication, and were further reduced between 1947 and 1954 to 1.3 per 100 sq. ft. Presumably most of the seedlings present in the pretreatment count were destroyed: most of the 6.9 plants per 100 sq. ft. reported in 1947 probably came in on the disturbed ground. The survivors of this generation in 1954 are found in the 4.7 plants per 100 sq. ft. in the 9- to 10-year age class. The 1.5 plants per 100 sq. ft. which were less than 3 years old in 1954 suggest that sagebrush is increasing. Significantly, these small plants were found almost entirely in the western ends of the south and middle pastures where grazing use has been heaviest.

DEER WINTER RANGE REVEGETATION

At the termination of our 5-year cooperative agreement with the Idaho State Fish and Game Department to investigate possibilities of improving depleted big-game winter ranges by artificial revegetation, a new agreement was drawn up under which the browse revegetation studies will be expanded and intensified. A qualified assistant has been hired by the State of Idaho and assigned to work full time at the Boise Research Center on this cooperative research. The State will also furnish certain temporary help that may be needed on the project. The new agreement, therefore, makes available to the program about twice the personnel formerly working on it.

The major portion of the program for the next 3 years will be devoted to learning more about planting techniques for bitterbrush, proper depths for seeding on different slope aspects, the most important causes of mortality in the early seedling stage, and how to cope with these causes as well as harmful effects of rodents and game on establishment, growth, and survival of artificially planted bitterbrush.

Experimental plantings of nursery-grown bitterbrush will be made on the game winter range to develop a sound technique for this revegetation method. Doubtless browse restoration by planting of nursery stock is more costly initially than direct seeding, but if an effective method insuring a high degree of survival can be perfected, it may be the more economical.

While the revegetation studies are in progress, established stands of bitterbrush, natural and artificial, will be observed to get a better understanding of the species, its reproduction and growth, and its relations with associated species and site factors. Such information will guide planting programs, making possible their sound planning, from selection of site to type of management required to maintain the plantations at maximum productivity.

The search for other suitable browse species will be continued. As propagative material becomes available, these species will be

tested in adaptability plots on the winter range. Among these, as among species already considered potentially useful, some may be difficult of establishment because of indifference to ordinary methods of breaking seed dormancy. If such species should be desirable for revegetation, an attempt will be made to learn the required pre-treatment for enhancing germination.

Progress has been made in developing methods of eradicating competing vegetation in order to plant browse successfully in annual types. There are game winter ranges lacking browse that are of perennial type, however, on which very little work has been done. To restore browse species on these sites we need to know the amount of cover reduction necessary and methods of attaining that reduction. Accordingly an extension of browse-seeding research is being made to these perennial types.

WATERSHED MANAGEMENT RESEARCH

The territory now served by the Intermountain Station embraces all or part of four major river drainage basins. West of the Continental Divide in Montana, Idaho, Wyoming, and eastern Washington are the numerous tributaries of the Columbia River whose waters provide a tremendous potential for hydroelectric power in a rapidly growing Inland Empire. East of the Continental Divide in Montana are the headwaters of the great Missouri River which deliver water to the agricultural Plains States. To the southeast and south in Wyoming, Utah, and Nevada are the Green, Fremont, Paria, Kanab, and Virgin tributaries of the deeply entrenched Colorado River. In Utah and Nevada also are the extensive arid valleys of the Great Basin into which flow many small but vitally important streams from surrounding mountains and plateaus.

In all four major drainage basins there are serious problems of sedimentation, floods, and short water supplies. These water problems have arisen in part from natural causes. It is entirely normal for streams to carry some sediment, to reach flood stage from time to time following unusually deep snows or heavy rains, and to reach low stages of flow during prolonged drought. But these problems of too little, too much, and too muddy water can not be blamed entirely to natural causes, for man's occupancy and use of the land has aggravated them.

Occupancy and development of downstream areas has been an important contributing factor. The choice locations for cities, farms, factories, and for transportation and communication, have been on the valley flood plains of perennial streams. These locations are precisely where recurring damage from floods and sedimentation is inevitable. Even where developments were extended to more elevated and remote terraces and benches, water problems followed. In some places, developments exceeded the available water supply. Where dams, reservoirs, and canals were built to conserve and deliver water, their very locations across channels and arroyos made them vulnerable to damage by floods and sedimentation.

Added to these downstream aggravations has been unwise use of the watershed lands. Wild fires have bared vast areas of forest and rangelands over the years and are a continuing menace. The range forage cover has been depleted by overgrazing on high-elevation summer range, on foothill spring-fall range, and on low-elevation winter range. Logging operations have thinned the forest cover and carved roads and skidways up and down steep slopes. Highways, mining operations, smelter fumes, and other construction work have added to plant cover depletion and to baring and compaction of soil.

These disturbances on the watershed lands have lessened their stability and their capacity to control runoff. Accelerated soil

erosion has decreased the fertility and productivity of the land. Depletion of the natural plant cover has probably affected the annual and seasonal yields of water in local areas, though the magnitude of these changes are not as yet very well known. It is known definitely, however, that thinning the plant cover on watershed slopes in some areas has stepped up flood peaks as much as a hundredfold and has increased the sediment load of streams 1,000 times or more above normal. These are ruinous changes in a territory where usable water and supplies of wood and forage are indispensable.

Correction of present unsatisfactory watershed conditions and prevention of further deterioration must start on the land where rains fall and snows melt. More and bigger dams, though needed in many places, will not keep soil productive and in place on watershed slopes, nor will they affect the runoff behavior of the lands. The problem is to determine where, when, and how much the timber and forage resources can be utilized without accelerating erosion, increasing floods, and stepping up the sediment load of streams, while maintaining maximum yields of water.

These objectives pose many difficult technical problems. For one thing, the Station territory embraces a wide variety of physiographic and climatic conditions. Within each of the four major river drainage basins there are mountains receiving 25 to 65 inches of precipitation per year, foothill and benchlands receiving 15 to 25 inches, and valleys and plains where annual precipitation averages 5 to 15 inches. Within these broad climatic zones are variations in topography, soil, plant cover, and land use practices, each of which has a bearing on the stability and hydrology of the land.

Vegetation, whether in the form of trees, shrubs, or herbs, exerts influences in two directions, hydrologically. Soil stability and control of flood flows tend to increase with amount of vegetation and litter, yet plants both dissipate and use water and thus diminish the amount of rain and snow that can become available as streamflow. Thus it is not hydrologically rational for watershed management to provide maximum soil stability and flood control and maximum water yields from the same land area at the same time. There must be a compromise between these objectives, and in this western area where wild land productivity and the longevity of water storage reservoirs are vital, the choice is clear. That choice lies in the direction of finding the plant cover that will protect the soil and minimize flood discharges while utilizing and dissipating the least water.

During the past year further progress was made in the search for useful guides for the management of the watershed lands in the Station territory. Some of these efforts were focused on soil stability, some on controlling runoff, and some on water conservation.

SOIL STABILITY ON FOREST LANDS

Rapidly increasing demands for sawtimber and salvage operation in bug-killed spruce have extended logging operations into increasingly remote and steep forest lands. Evidence of accelerated erosion points directly to the need for more reliable methods and standards for controlling runoff and maintaining the stability of haul roads and skid trails. This problem is especially acute on the loose granitic soils of Idaho.

In the first phase of this effort observations were made on five timber sale areas in the Boise National Forest. In this study, some 289 groups of observations were made on haul roads and 71 skid trail situations.

Observations on haul roads showed that erosion increased with increase in slope gradient, but in varying degree, depending upon their location. Gully erosion did not occur on ridge locations until road gradients exceeded 14 percent. On hillsides, gully erosion occurred where gradients exceeded 9 percent, and in valley bottoms they occurred where gradients exceeded 5 percent. Length of slope on which runoff accumulates also appeared to be a critical variable. The maximum spacings of cross ditches which appeared to be effective for preventing rill and gully erosion on different gradients were as follows:

Road gradient Percent	Cross ditch spacing Feet
5 or less	100
5 - 9	75
10 - 14	50
14 - 20	25

Observations on skid trails indicated that rill and gully erosion can probably be controlled by installing slash gully plugs, log water bars, or cross ditches, at the following spacings:

Skid trail gradient Percent	Control structure spacing Feet
10 - 20	60
20 - 40	30
40 - 60	20

The above standards are suggested as tentative guides for haul roads and skid trails in ponderosa pine forests having soil derived from coarse granite.

The findings of this observational study were used as a basis for initiating a more comprehensive test of erosion-control methods on haul roads and skid trails in ponderosa pine lands. In this study, provision has been made for evaluating the erosion-control effects of road gradients, spacing of cross ditches, and grass seedings. On skid trails, the study will test the effectiveness of water bars and scattered slash, as well as spacing of these controls, effects of gradients and of location of skid trails with respect to ridges, bottoms, and side slopes.

This study was undertaken in cooperation with the Boise and the Payette National Forests on four different ponderosa pine habitats. On the Boise National Forest, one study area is situated near the upper elevational limits of ponderosa pine (Beaver Creek) and one near the lower and drier limits (Grape Mountain). On the Payette National Forest, one area is situated on fine-textured granitic soil (Salmon River South Fork) and one on clay soil derived from basalt (Little Weiser River). All installations were completed last year.

All phases of a long-term study of the effects of logging disturbance and methods of cutting on sediment production from virgin ponderosa pine lands at the Boise Basin Experimental Forest were completed last year. The study is being made on 20 compartments of about 100 acres each in cooperation with the Division of Forest Management Research. Sixteen of the compartments have been cut and logged and four have been kept in virgin condition. Erosion surveys have been made on all compartments prior to cutting and logging for comparison with the followup surveys. Cross section measurements have been made on representative segments of logging roads, skid trails, and drainage bottoms. Dams and sediment traps have been installed and profiled for storage capacity on representative subbasins in each of the 20 compartments. The stage is thus set for beginning measurements in 1955 of erosion and sediment production as affected by different methods of harvest cutting and logging.

SOIL STABILITY ON RANGELANDS

How much plant and litter cover is necessary to maintain the stability of soil and minimize summer storm runoff is one of the major questions involved in management of range-watershed lands. Closely related is the problem of restoring an adequate cover on lands in unsatisfactory condition. Efforts to find answers to both questions have been concentrated on the subalpine herbaceous summer range at the Great Basin Research Center in central Utah; on high-elevation aspen-herbaceous range at the Wasatch Research Center in northern Utah; and on foothill, spring-fall range at the Boise Research Center in southwestern Idaho.

Previous study at all three locations indicated that both soil losses and summer storm runoff increased at accelerated rates under

the impact of high-intensity rains when progressively more than about one-third of the soil was bared. Further evidence of the ground cover-rainfall intensity relation to erosion and runoff was obtained last year at both the Great Basin and Wasatch study areas.

At the Great Basin, 32 summer rains fell on the A and B experimental watersheds but none of these storms caused runoff or soil loss from either watershed. Effective control of these storms is attributable in part to the small volume and low intensity of rainfall, but more particularly to the amount of vegetation now on the two areas. More than half the ground surface on Area A now has a plant cover as compared to less than a 20-percent cover in earlier years. Area B has a similar plant cover, whereas in 1951 and 1952 its plant cover was only about 20 percent. The quick recovery of Area B was accomplished by plowing and seeding the area to grass in the fall of 1952.

The records show that whereas neither Area A nor B produced runoff or sediment in 1954, equally small and low-intensity rains caused runoff from Area B in 1951 and 1952 when it was in depleted condition (table 11). That storm runoff can be caused by less than 0.20 inch of rain indicates the vulnerability of range-watershed lands in this area.

Table 11.--Comparative runoff behavior of Area B during three of the largest summer rains in 1954 and during comparable storms in 1951 and 1952

1954		1951 and 1952	
Rainfall	Runoff	Rainfall	Runoff
Inches	Cu.ft./A.	Inches	Cu.ft./A.
0.19	0	0.20	132
.17	0	.15	24
.14	0	.13	46

At the Wasatch Research Center, 25 rains fell on the range plots in the head of Parrish Creek during the past summer. Total rainfall amounted to 7.51 inches. The volume of individual rains varied from 0.02 to 1.17 inches and maximum 5-minute rates varied from 0.12 to 2.28 inches per hour. Eight rains produced runoff and caused soil erosion, but the only areas that lost any measurable quantity of soil or produced any significant amounts of runoff were those that have been kept denuded of vegetation (table 12). As in previous years with even greater intensities of rainfall, the areas having 60 percent or more of the ground covered by plants and litter have lost no soil and have permitted less than 5 percent of the rainfall to run off as overland flow.

Table 12.--Average amounts of soil eroded and rainfall runoff under four range conditions at Parrish Plots, summer of 1954

No. of plots	Plant cover type	Ground cover	Soil eroded	Rainfall runoff	
		Percent	Cu.ft./A.	Cu.ft./A.	Percent
3	Bare	0	122	4,379	21
3	Herbaceous	60	0	441	2
6	Snowberry-sage	70	T	465	3
4	Aspen-herbaceous	88	0	369	2

At the Boise Research Center a battery of four runoff and sediment measuring plots was installed in the foothill zone of the Boise River watershed in cooperation with the Boise National Forest. These plots will be used to determine the effectiveness of artificial seeding and exclusion of grazing for stabilizing the highly erosive granitic soils of that area.

FLOOD CONTROL

Two radically different types of floods occur in the Station territory. One is the snowmelt flood which usually occurs in spring or early summer. These are generated from the prolonged melting of deep accumulations of snow on the more elevated watershed lands. Because of the relatively slow release of water from the snowpack and because very little runoff occurs as overland flow, these flood discharges never attain very high peaks, though strong flows may be sustained for weeks at a time. The other type is the flood from brief torrential summer rains. These can be generated by rains of less than 1 inch when the rain falls faster than it can be absorbed by the soil. Notwithstanding the small volume of rain required, these summer floods can discharge in excess of 1,000 cubic feet per second per square mile of watershed drained and can transport tremendous quantities of sediment, including boulders weighing more than 100 tons.

Flood control studies at this Station have been devoted mainly to the summer storm type and much of that effort has centered on the Davis County Experimental Watershed in northern Utah. Analysis of the behavior of three of the subwatersheds in that area covering the period 1936 to 1953, inclusive, show how restoration of plant cover on headwater flood-source areas has affected annual and seasonal water yields, as well as stormflow discharges.

The three watersheds have undergone different treatments and have different flood histories. Centerville watershed, the southernmost, has never been abused and has not produced any mud-rock floods since long before settlement. Parrish watershed, immediately adjacent to Centerville, produced four major mud-rock floods in 1930 when about 10 percent of the headwater lands was in depleted condition. The flood-source areas were contour trenched and seeded to grass in 1934 and 1935. It has not flooded since 1930. Halfway watershed, some 3 miles north of Parrish, was in equally depleted condition in 1930. Very little improvement work was done in this watershed and the headwater areas are still depleted. This watershed produced mud-rock floods in 1923, 1930, 1936, and 1947. The last occurred during a rain of only 0.79 inch in which the maximum rate of rainfall for 5 minutes was 4.92 inches per hour.

Since 1936, Centerville and Parrish watersheds have each been subjected to six summer rains of equal or greater volume and rate than the rain which caused the 1947 flood in Halfway Creek, but neither has produced any semblance of a flood. Their streamflow records show that the volume of storm runoff was only about 0.01 areal inch, or about 1 percent of the rainfall. Because there was practically no evidence of overland flow on either of the watersheds, it is apparent that the minor and short-lived rise in streamflow was due almost entirely to the rain that fell in each creek channel.

Further analyses were made of the 17-year streamflow records from Parrish Creek to determine whether the watershed improvement work for flood prevention had affected annual and seasonal water yields. Centerville Creek was used as a comparison because there has been little change in watershed conditions on that area during the period of record.

Annual runoff for the period of record has averaged 12.74 areal inches from Parrish watershed and 13.17 inches from Centerville. Similar fluctuations in each watershed occurred from year to year by reason of annual fluctuations of precipitation. Over the period of study, annual yields in both watersheds have a slight upward trend, reflecting greater than average precipitation in recent years. However, Parrish watershed yielded about 1 inch more runoff annually than Centerville during the first 5 years of record, whereas in recent years Centerville has been yielding about 1 inch more than Parrish.

Parrish Creek runoff during the fall, winter, and late summer months has not differed significantly from that of Centerville. Parrish Creek streamflow has diminished during the snowmelt months of March, April, and May, on the order of 0.36 to 1.25 inches per month. Flow in June, however, has been slightly increased.

These analyses show that restoration of plant cover on depleted headwaters of the Parrish watershed accomplished more than prevention of devastating summer storm mud-rock floods. It also lessened the

hazard of spring snowmelt floods at a time of year when water supplies are generally ample, and it strengthened June streamflow without significantly diminishing water yields in late summer.

An investigation of soil moisture on representative portions of the headwater lands in Parrish watershed at the end of the growing season last fall suggested why spring runoff has been lessened. On areas that have purposely been kept denuded, the soil mantle to a depth of 6 feet contained about 3 inches more water than areas having an annual weed cover, and about 8 inches more than those having a two-story aspen-herbaceous plant cover. When these depletion moisture contents are compared with the capacity of the soils to hold water against the force of gravity, they show that less than 7 inches of winter precipitation will recharge the soil on the bare areas, whereas from 10 to 12 inches of water will be required to recharge the plant covered areas (table 13). Further investigations of these moisture recharge relations are planned for 1955.

Table 13.--Recharge requirements (water storage deficits) of 6-foot soil mantles on Parrish watershed headwater areas at end of growing season, 1954

Plant cover conditions	Field moisture capacity	Depletion moisture content	Recharge requirement
	Inches	Inches	Inches
Bare soil	20.56	13.68	6.88
Annual weed	20.59	10.44	10.15
Perennial grass-weed	20.51	8.43	12.08
Sagebrush-herbs	1/ 18.00	6.39	11.61
Aspen-herbaceous	16.19	5.46	10.73

1/ Estimated value

UPSTREAM WATER CONSERVATION

Watershed management on rangelands must strive for plant cover and soil conditions that will minimize soil losses and storm runoff, and at the same time produce maximum forage yields at the least cost of water. Last fall further information was obtained at the Great Basin Research Center on the relative efficiency with which several kinds of summer range plants utilize moisture for forage production and the water storage deficits they create in the soil mantle by the end of the growing season. The study was made on a high-elevation summer range where winter snows always provide more than enough water to saturate the soil mantle each spring. The snow water that is surplus to the soil-moisture storage deficit in the fall is the principal source of water for perennial streamflow next year. The moisture

that is retained in the soil mantle following disappearance of snow, plus summer rainfall, is available for plant growth.

In 1952 and 1954, comparable information was obtained on three types of range cover, smooth bromegrass, Kentucky bluegrass, and mixed weeds. During the growing season of 1952 precipitation totalled 3.47 inches, and in 1954 it was 5.00 inches.

On each of the three plant cover type areas, soil moisture deficits and forage production were nearly the same in the 2 years of record notwithstanding about 1½ inches more summer rainfall and evapo-transpiration loss in 1954 (table 14). As in 1952, smooth bromegrass

Table 14.--Soil-moisture deficits, evapo-transpiration losses, and forage production on high-elevation summer range, Great Basin Research Center, 1952 and 1954

Plant cover types	Soil-moisture deficit		Growing-season evapo-transpiration		Forage production	
	1952	1954	1952	1954	1952	1954
	Inches		Inches		Lbs./A.	
Smooth bromegrass	7.86	7.81	11.33	12.81	4,181	4,138
Kentucky bluegrass	6.31	6.98	9.78	11.98	2,425	3,000
Mixed weeds	5.49	5.24	8.96	10.24	700	700

produced most forage per inch of water available for growth but it also dried the mantle most. Kentucky bluegrass areas were less efficient in utilizing water for forage production, but left the mantle in condition to yield about 1 inch more water next year. The areas with thin weed cover left the mantle in condition to yield from 1 to 2½ inches more water in the following year than the grass-covered areas but, on the other hand, they produced only one-sixth to one-fourth as much forage. Moreover, numerous tests have shown that thin weed stands are very unsatisfactory for maintaining soil stability and for controlling destructive flood runoff.

The differences exhibited by these three types of cover, though based on limited and exploratory data, indicate how and to what extent alterations in summer range plant cover can affect both forage production and water yields. They substantiate the well known facts that plants require water for growth and that some plants are more efficient in their use of water than others. It is planned to continue studies in this field.

During the past summer the installation phase of a soil-moisture study was completed at the Wasatch Research Center. This study involves 16 plots, each of which has been planted to a mixture of summer range grasses. Each plot is equipped with Colman fibreglass soil-moisture

units to depths of 6 feet, a surface runoff subplot, and precipitation gages. Following establishment of the grass stand, it is planned to use this installation to determine the effects of seasonal grazing on productivity and hydrologic behavior of the study areas.

SOIL STRENGTH SURVEYS

During the past year several studies were made for the Corps of Engineers on the trafficability of soils. One phase of this effort was devoted to development of methods for predicting soil-moisture contents. This involved study of rates at which soils gained and lost moisture on a variety of sites. Prediction equations were developed for three soil sites in the vicinity of Miles City, Montana, and for five sites near Rockford, Washington. The latter study will be completed early in 1955.

In a second phase of work, a soil-moisture-strength survey was initiated last summer out of the Wasatch Research Center. This survey will obtain information on soil strength characteristics at 148 sites in Utah, Nevada, and southern Idaho. Data at these sites will also be used to test the accuracy of soil-moisture prediction methods. This study is scheduled for completion in 1955.

FOREST INSECT RESEARCH

By the reorganization of the Department of Agriculture in November 1953 the Intermountain Station acquired the Division of Forest Insect Research, formerly under the Bureau of Entomology and Plant Quarantine of the Agricultural Research Administration. The Division maintains entomologists at Coeur d'Alene, Idaho and Ogden, Utah working on forest insect problems of the Intermountain region. The Coeur d'Alene laboratory has been established in the northern area for many years while the Ogden unit has been in existence since 1949. With the consolidation of the Intermountain and Northern Rocky Mountain Stations, headquarters for the forest insect studies have been established at Ogden. It is planned to move the personnel at Coeur d'Alene to Missoula in the near future.

The work of the Division falls into three rather distinct but related fields--research into the biology and ecology of forest insects as a basis for the development of satisfactory and economical methods of control; surveys to detect and appraise infestations to determine entomological soundness of control possibilities; and technical advice to all land managers in carrying out control procedures. Active cooperation with all land managing agencies, Federal, state, and private, is an essential part of all phases of the program.

RESEARCH

Forest insect problems in the Intermountain region are numerous and diverse. The region, extending as it does from Canada to Arizona and California, includes a wide variety of climatic conditions, forest types, and forest insects. It might be said that the Intermountain region has all the insect troubles of other western forest areas plus some peculiar unto itself. The primary insects include the tree-killing bark beetles such as Dendroctonus spp. and defoliators such as the spruce budworm, pine butterfly, tussock moth, and needle miners. There are, however, a number of insects of lesser importance that do cause considerable damage and should be the subject of future research. During 1954, with the exception of one cooperative study with the Division of Timber Management Research at the Boise Basin Experimental Forest, all research reported herein was conducted from the Coeur d'Alene laboratory. The Boise Basin study was conducted from the Ogden laboratory.

Engelmann Spruce Beetle

With the development of a serious and extensive outbreak of Engelmann spruce beetle in Montana and Idaho in 1952 a program of research was started in order to determine facts that would aid in control of the infestation. This work was continued in 1954. Facts developed

reveal that there are differences in the behavior of the beetles from that noted in the Colorado outbreak. The number of attacks per square foot of bark surface was less and the variation in seasonal temperatures seemed to vary the percentage of 1- and 2-year broods within areas more strongly than in Colorado. The facts have a bearing on control plans. While trap trees for control of bark beetles have been tried with a number of species, most tests have not proved effective. Research with trap logs in the Montana outbreak indicates that trapping spruce beetles by felling trees may have distinct possibilities in control programs. Data are being accumulated on the natural enemies of the spruce beetle.

Risk Rating of Ponderosa Pine

In the eastside ponderosa pine stands of California and Oregon it is possible to classify individual pines by a combination of visible characters and to assign them a rating of risk as to degree of susceptibility to beetle attack. Removal of high-risk trees has proved an excellent method of preventing losses from beetle attack. In 1950 an experiment was started in western Montana to test the effectiveness of this system of rating under conditions in that area. Facts have been developed on stand structures, distribution and characteristics of high-risk trees, and rate of beetle-caused pine mortality. The study has already shown some positive relations between the occurrence of high-risk tree volumes and certain stand characteristics such as age, growth rates, site quality, and previous beetle-caused mortality, as well as a preference by the beetles for trees classified in the high-risk category.

Selective Logging to Control Pine Beetles

Following the classification of ponderosa pine stands by the risk-rating system, selective logging is done to remove the high-risk element of the stand. This is commonly termed sanitation-salvage cutting. In 1950 several hundred acres of pine were logged in Montana on this basis. By this method attempts are being made to "beetle proof" the residual stands during the 30-year cutting cycle immediately following the sanitation-salvage cut. The 1954 survey indicated that pine mortality was appreciably less during 1953 and 1954 on the treated areas than on adjacent uncut areas.

Douglas-fir Beetle

During 1954 it was decided to establish a long-term study of the Douglas-fir beetle in the Intermountain area. As a first step a problem analysis is under way, and considerable factual information has been accumulated such as resource statistics, economic considerations in the utilization of Douglas-fir forest products, and the influence of beetle infestations on both the resource and the economy of the timber species. It was possible to observe and discuss the

progress of studies by Canadian entomologists which will aid in formulating plans for the study in this region.

Spruce Budworm

Research on certain phases of a study of spruce budworm has been under way for the past few years in Montana and Idaho. Because of the importance of the species in the Intermountain area, and because of interrelations between spruce budworm and Douglas-fir beetle, a long-term study of budworm is being planned. Trees heavily defoliated by budworm are more susceptible to attack by the bark beetle than non-defoliated trees. Plots have been established in the northern Rocky Mountains in order to study the biology and ecology of the species. Additional data were accumulated in 1954 to establish a correlation between the overwintering budworm populations and subsequent host tree defoliation. If completely satisfactory methods of measurement are developed from this study, it will be possible to forecast where heavy defoliation will occur.

Improvement of Insect Survey Methods

An important phase of the research program is the improvement of ground and aerial methods of forest insect surveys. At the Coeur d'Alene laboratory some studies were initiated in 1954. By field test an improved 2-inch scale compartment map proved very satisfactory for recording drainage and cultural features, timber type boundaries, sample strip lines, and locations of infested trees on sample strips. These maps were constructed from aerial photo strip maps obtained from the Division of Forest Economics Research. An improved method in the identification of external characteristics of beetle-attacked trees was developed which has value in dating the year of kill of trees attacked by Engelmann spruce beetles, and in properly identifying trees still containing active infestations of Douglas-fir beetle. The method will prove helpful in timber marking to remove infested trees.

Cooperative Study - Boise Basin

A study has been started on the Boise Basin Experimental Forest in cooperation with the Division of Forest Management Research. It is planned to study insect conditions and activities over a period of years in reserve stands of ponderosa pine following different methods of logging on a selective cutting basis. Selective logging in this area has been followed by excessive losses in the residual stand. The long-term study may reveal the factors causing losses from insects in these stands.

INSECT SURVEYS

The Division has the responsibility for detection and appraisal surveys under provisions of the Forest Pest Control Act. One problem

is to develop cooperative detection surveys to discover epidemic tendencies in populations of forest insects, and another is to appraise the seriousness of the infestations and report to land managers, regardless of land ownership. The total acreage of forest lands, commercial and noncommercial, in the area covered by the Intermountain Station approximates 88 million acres. Suitable detection reporting over such an acreage can only result from a highly developed cooperative system including all individuals interested in forest protection. Appraisal surveys are highly technical and demand the best analysis of each situation by trained entomologists.

In the southern part of the Intermountain region under the jurisdiction of the Ogden laboratory staff, survey needs in 1954 were numerous. One was a serious pine butterfly infestation on the Boise National Forest. It was necessary to conduct surveys prior to the aerial spray operation, and afterward a survey was made to determine the effectiveness of control and locate areas that might need additional treatment. The continuing bark beetle control project on the Dixie National Forest and Bryce Canyon National Park necessitated several surveys during the season. In addition, areas where cooperators reported unusual insect activity were examined to determine the status of infestations, and reports were issued.

Within the area covered by the Coeur d'Alene laboratory the major survey effort was made to determine the status of the Engelmann spruce beetle, mountain pine beetle in lodgepole pine, and spruce budworm in Douglas-fir and true fir. Cooperative aid in detection revealed a number of less important infestations that were examined by the entomologists. Aerial observations proved highly successful in revealing general conditions and also aided in locating developing centers that could be checked by ground surveys.

TECHNICAL ADVICE ON CONTROL

The Division has responsibility for technical advice to all land managers on insect control projects. Station technical personnel assist in planning control projects, recommend methods, materials, and timing, train project personnel in control procedures, inspect operations to see that effective work is being done, and analyze results. The work load varies greatly and during periods of severe outbreak conditions may overtax available technical personnel, requiring help from detailers.

The Ogden laboratory had two important control projects in its area during 1954 on which it furnished technical assistance to the operating agencies. Entomologists assisted in the planning for control of the pine butterfly aerial spray project on the Boise National Forest, gave on-the-ground technical advice to insure proper timing and application of aerial sprays, and determined results of the operation. The same type of technical service was furnished to National

Forest Administration and the National Park Service of the Department of the Interior in connection with the cooperative project against the Black Hills beetle on the Dixie National Forest and Bryce Canyon National Park.

The Coeur d'Alene laboratory furnished technical assistance to land managers in the current large-scale project to control the outbreak of Engelmann spruce beetle in the northern Rocky Mountain region where more than 2 billion feet of spruce has been killed since 1952. Control is being attempted primarily by logging with some use of trap logs in areas where logging is scheduled but not yet started. A large share of the technical assistance effort in 1954 consisted of correlating the biological developments of the insect with the timing of treatment of the trap logs.

FOREST DISEASE RESEARCH

In common with other forested sections of the United States, the Intermountain area has important forest disease problems. In eastern Washington, northern Idaho, and western Montana, pole blight of western white pine is certainly the most serious at present. Found extensively throughout most of the range of this species in the northern Rocky Mountains, it is particularly disturbing because it attacks and kills young pole-size stands which are just approaching their period of most valuable growth. Neither its cause nor its means of spread are known.

Blister rust of western white pine is still very serious. The Division of Blister Rust Control in Region One of the Forest Service is working full time on it. Close cooperation exists between this Division and Station pathologists, entomologists, and silviculturists assigned to the Inland Empire Research Center, Missoula Research Center, and Missoula Insect Laboratory.

Other important disease problems of the northern forests include:

Dwarfmistletoe. A serious loss factor in western larch, Douglas-fir, and lodgepole pine; somewhat less serious in ponderosa pine.

Heart rots. Infect grand fir and western hemlock at an early age and lead to substantial losses.

Diseases following logging damage. Studies needed here and in estimation of defect to aid forest management.

Root rots. Are causing serious losses to western white pine and Douglas-fir particularly.

Needle casts. Now important on Douglas-fir, ponderosa pine, and western larch.

Pine rusts. Causing defect losses in the so-called inferior species now coming into increasing use.

Deterioration of fire- and insect-killed timber. A serious matter brought into sharp focus by recent Engelmann spruce beetle attacks.

Further south in the Station area, Elytroderma needle disease of ponderosa pine is probably most noteworthy, being particularly severe at the present time in parts of central Idaho. Trees become progressively weakened and usually die. Unfortunately, losses have been heaviest in the younger age classes--the trees normally left as a reserve stand in partial cutting operations.

The following disease problems also stand out in the central-southern area:

Dwarfmistletoe. Serious on lodgepole pine, ponderosa pine, and Douglas-fir.

Postlogging mortality in ponderosa pine. A complex situation with insects and other causes tied in with diseases. Fomes annosus (root rot) appears to be the most important disease involved.

Pine rusts. Serious on lodgepole pine and ponderosa pine.

Leaf and twig disease on aspen. Causing widespread damage; kills trees in patches.

Heart and butt rots. Need studies of this important problem in Engelmann spruce and alpine fir, including investigation of external indicators.

In the face of so many critical problems, the small force of disease workers at Intermountain Forest and Range Experiment Station is inadequate indeed. It is essential that planning of research projects be highly selective so that efforts are directed against the diseases of highest priority. In deciding which studies to make first, due regard is paid to existing research facilities, particularly experimental forests, so that maximum help can be obtained from Station silviculturists and entomologists.

All disease research is closely integrated with activities in the same field by other stations and institutions. For example, the University of Idaho and Intermountain Station have for some years worked as partners in studies of pole blight of western white pine. Frequent meetings and free interchange between individual workers in the field keep this cooperation real and up-to-date.

Three pathologists and one soils scientist are presently on the staff of this Station. Two pathologists and the soils scientist are stationed at the Inland Empire Center and are working on the pole blight project. The other pathologist is stationed at Logan, Utah and is concerned primarily with Elytroderma needle disease.

Again in 1955 Forest Disease efforts at the Intermountain Station will be concentrated against pole blight of western white pine and Elytroderma needle disease of ponderosa pine. Observations will be made of other diseases encountered to accumulate a fund of information against the day when it will be possible to investigate these additional disease problems. Some time must be devoted to requests for information on tree diseases from practicing foresters and the general public.

POLE BLIGHT OF WESTERN WHITE PINE

For the first time since investigations of pole blight of western white pine began, the Station was able in 1954 to launch an integrated attack at the phases of the problem being studied by the Forest Service. Forest pathologists, a soils scientist, and silviculturists working side by side provide a team approach to unveil this mysterious malady and point up avenues of effective control. Although considerable time was required at the start for equipment development and construction of a soils-pathology laboratory at the Inland Empire Research Center, progress was made during the season. Major accomplishments are:

1. A study of lesions associated with pole blight of western white pine indicates that growth reduction is a symptom invariably associated with pole blight and suggests that lesion development and crown decline follow growth reduction at extremely variable rates. A report has been prepared and submitted to the Journal of Forestry for publication.

2. Physiological studies of Leptographium sp. have disclosed no different species among isolates of this fungus obtained from pole-blighted white pines. Leptographium sp. has been extensively studied during the past 6 years because it is one of the common fungi obtained in isolation studies of pole blight. Studies of physiological aspects, including nutritional requirements, were carried out on four isolates of this fungus. Although no significant differences in growth requirements were found to exist between the four isolates, general temperature, pH, and vitamin requirements were determined and reported for the first time for members of this genus. The results of this study were submitted in a dissertation to fulfill Ph.D. requirements and will also be submitted for publication in Mycologia.

3. Results from inoculations made with Leptographium sp. show that this fungus, or at least the isolates of this fungus used in the tests, is not the primary cause of pole blight. Final observations made on inoculation plots established in 1949 show that none of the inoculated trees have produced the characteristic symptoms of pole blight to date.

4. Grafts of pole blighted scion material on healthy stock have been successful. The results of grafts made in the spring of 1954 on 6-year-old white pine stock are shown in table 15. Scion material was collected from the upper, middle, and lower crowns of 6 healthy and 14 diseased trees.

Table 15.--Number of grafts made and number living at end of first growing season

Scion condition	Total grafts	Grafts dead	Grafts living: 1954 growth developed	Grafts living: No 1954 growth
Blighted	168	82	27	59
Healthy	62	25	26	11

Successful grafts were obtained using scion material from trees in all stages of disease and from the 3 portions of the crown sampled.

5. The initiation of a coordinate soils-rootlet mortality study marked the beginning of a more concerted effort to determine the cause of the pole blight disease. In healthy and diseased stands of various site classes root samples from three successive 1-foot depths were collected and healthy and dead rootlets tabulated. Intensive soil sampling was done to determine possible relations between soil characteristics and the condition of the root systems in the various stands.

6. Distribution surveys of white pine pole blight along the southern limits of the disease on the St. Joe National Forest indicate that most of the larger diseased areas have been found. No pole blight was found in stands classified as healthy in 1953, but in several instances pole blight was found in what were formerly healthy portions of diseased stands. The established range, the southern limits, and the estimated acreage of the disease remain about the same.

7. Damage appraisal surveys in four pole-blighted stands each on the St. Joe, Kaniksu, and Coeur d'Alene National Forests indicated that from 50 to 80 percent of the white pine poles are either blighted or blight killed.

8. Analysis of records from white pine plots established and thinned prior to the existence of pole blight in the stands shows that an abrupt decrease in diameter and volume growth and an increase in mortality coincided with the appearance of pole blight in the stands.

BLISTER RUST RESISTANCE IN WESTERN WHITE PINE

Mass artificial inoculations of western white pine progenies during 1953-54 to test their resistance to blister rust were highly successful in producing infection. Success of the tree breeding project aimed at producing a rust-resistant white pine depends in part on

satisfactory methods of artificial inoculation which secure heavy and uniform inoculation in order to test the resistance of each progeny to the disease in the minimum time. That the mass inoculation method used in 1953 was successful is demonstrated by the fact that needle spotting resulted on all progenies inoculated. Inoculations were made in the fall of 1954 on 1-0 progenies to be outplanted in 1956 and on 2-0 progenies inoculated in 1953 to be outplanted in 1955. To date, approximately 15,500 plants have been inoculated at least once, over one-half of which will have been inoculated twice prior to outplanting in 1956.

PONDEROSA PINE NEEDLE DISEASE

This native disease has been known for many years to occur throughout most of the range of ponderosa pine. It is not a recent invader of this region; it was reported from the Deadwood area of the Boise National Forest over 40 years ago.

Studies, which were initiated in central Idaho during 1948 on the needle fungus (Elytroderma deformans) were expanded in 1951. The main results of these studies, which have not been previously summarized, are:

1. The greatest intensity of infection on the disease areas occurred in 1950 and 1951.

2. Trees recorded as lightly infected in 1951 are still lightly infected, indicating individual resistance to the pathogen.

3. Mortality has occurred only among those trees that were classified in 1951 as "poor" or "very poor" in vigor because of their severely diseased condition.

4. Losses have been confined almost entirely to the younger age classes. The largest tree killed was 28 inches d.b.h. On 6 plots in heavily infected mature stands 13 or 8.1 percent of the total of 161 trees died between 1951 and 1954, resulting in a volume loss of 6,220 bd. ft., or 4.3 percent of the original volume. Increased losses have been the result of the cumulative effect of repeated annual infection rather than any material spread or increase in severity of the disease.

All evidence indicates environment to be highly important in development of the fungus. There has been no material increase in size of the areas on which the pathogen was observed to be abundant and destructive as early as 1946 or 1947, the years in which it first came to attention as epidemic in Idaho. Severe damage by the disease seems to be confined to (1) the upper altitudinal limits for ponderosa pine on south and west slopes and on ridge tops, where the tree is not

reproducing satisfactorily and intergrades with such species as Douglas-fir, larch, lodgepole pine, alpine fir, and Engelmann spruce; (2) cool basins; and (3) cool ravines.

The behavior of the fungus appears to be no different on the Bitterroot National Forest than elsewhere in the Intermountain area. It was not noted as present or destructive generally, but appeared to be confined to certain areas where environmental conditions evidently are favorable for the pathogen.

Very few young ponderosa pines less than 5 feet in height appear to be susceptible to the fungus.

Field spray tests on Elytroderma deformans and subsequent laboratory studies, indicated that all seven fungicidal materials employed in the experiments were highly effective in preventing spore cast and germination.

All attempts to grow the fungus in culture have been unsuccessful. It is doubtful whether this organism can be grown in culture by any method now in use.

CONSULTATION

Numerous requests for identification and suggestions for control of tree diseases were received the past year. They came from foresters managing public or private forest lands and from persons concerned with damage or loss of yard trees. In all cases available information was provided. Where it could be arranged in connection with travel to and from research projects, the afflicted areas were visited and advice given on the ground.

FOREST-FIRE RESEARCH

Consolidation of the old Northern Rocky Mountain and Intermountain Stations brings a fire-research program for the first time to a vast area of the Inland West. The new research territory, encompassing nearly one-sixth of the land area of the United States, contains somewhat less than 100 million acres of forest lands and a vast area of rangelands requiring protection from fire. Today, as when forestry programs first started in this region, fire control and hence fire research is a fundamental element of sound management. There is still plenty of opportunity for pioneering in these ventures. The size and challenge of the fire-research job is shown in table 16.

Table 16.--Forest fires in the Intermountain Station territory

State	Forest area needing first protection	Average annual number of fires 1/	Average annual area burned 1/
	M acres		Acres
Montana	25,155	953	29,980
Idaho	29,081	1,555	62,557
Washington (northeastern)	3,857	342	12,986
Wyoming (western)	8,418	173	5,181
Utah	21,375	175	3,316
Nevada	13,844	68	4,951
Total	101,730	3,266	118,971

1/ Basis U. S. Forest Service Annual Fire Reports 1929-1953, Washington and Wyoming figures prorated from state totals.

FOREST-FIRE LABORATORY

During 1954 a forest-fire laboratory was organized at Missoula. The laboratory has a dual function: (1) to perform fire research for the special problems of the forests and ranges of the Inland West, and (2) to carry on basic fire research that may have eventual application in any region. The forest-fire laboratory is organized to provide a task-force approach to the various fire-research problems through concentration of effort at a research center and cooperation with a score of private, state, and Federal agencies. A field arm of the laboratory will be maintained at the Priest River Experimental Forest.

The advance of the fire phase of forestry science is dependent in large measure on fundamental knowledge of two highly important factors--fuels and weather. Each of these factors is being studied at the laboratory in the projects on logging slash, fire-danger rating, and lightning. Applied research is also an important part of the laboratory program. In cooperation with many forestry agencies of this region the laboratory provides research service on fire-weather instruments, fuel-moisture-stick manufacture, fire detection, aerial fire control, fire behavior, prescribed burning, fire-control planning, and statistical analysis of regional fire-control problems.

FIRE-DANGER RATING

New Burning-Index and Fire-Danger Meter

The Model 7 burning-index and fire-danger meter was issued for operational use during the 1954 fire season. The meter is used to evaluate fire weather throughout Regions 1 and 4, by national parks, and by timber protective associations.

A major feature of the new burning-index meter is a seasonal or severity index which aids in interpreting fire-season trends through evaluating ½-inch-stick moisture over a 7-day period. Studies at the Priest River Experimental Forest have shown that seasonal loss or gain of moisture in heavy fuels may be evaluated through measurement of ½-inch-stick moisture. A long period of below par fuel moisture indicates the buildup of possibly dangerous fire conditions if accompanied by other factors contributing to high burning index. Incorporation of this feature in the new burning-index meter eliminates the calendar date factor used on previous meters. The result is a more reliable rate of burning index through spring, summer, and fall.

Other features of the Model 7 meter include greater sensitivity to both very high and very low burning index, a guide for forecasting tomorrow's ratings, and a conversion factor for estimating burning index at some other time and place on mountain slopes. Greater sensitivity to very high and very low burning index is made possible through use of multirange scales of relative humidity, fuel moisture, and wind velocity. This greater sensitivity makes the new meter especially useful in evaluating conditions for slash burning and prescribed use of fire. The predicting features of the meter enable the use of standard fire-weather forecasts for estimating tomorrow's burning index and fire danger. Conversion of burning index from the station where measured to some other point nearby and to some other time up to 8 hours is accomplished by a table which evaluates slope and elevation effects during 3 periods of the day. Burning-index conversions are especially useful in estimating rate of spread on going fires.

Use of the Model 7 meter throughout the Inland West enabled the first widespread operational test to be made of the many new features

in this system of rating burning index and fire danger. Results of the first year's use of the new meter are being carefully evaluated.

Fire-Danger-Rating System

In addition to the use of the new burning index meter, 1954 marked the standardization of many other phases of the fire-danger-rating system in the Intermountain Station territory. All agencies are now using the same forms for recording and reporting fire danger. Fire-danger-rating data from the entire 6-state area of the Station are now sent to the forest-fire laboratory at Missoula. Availability of these data will be an important factor in analyzing each fire season and in performing basic research in fire weather and fire-danger rating. Over 300 fire-danger-rating stations are now included in the program.

1954 marked the 21st year in which an analysis has been made of fire-season severity in the northern Rockies. The analysis shows that 1954 was the easiest fire season in Forest Service Region 1 since the rating system was started, rating only 13 percent of worst probable fire danger. During the period 1934 through 1954 there have been 3 fire seasons rated critical, 12 average, and 6 easy. A critical season has 68 percent or more of worst probable fire danger, an average season 33 to 67 percent, and an easy season 32 percent or less. The last critical fire season occurred in 1940. During the last 14 years there has been a remarkable period of noncritical fire weather in the northern Rockies.

Research in the special problems of fire-danger rating in Forest Service Region 4 was started in 1954. Visits were made to the Payette, Boise, Salmon, Challis, Targhee, and Teton National Forests and the Grand Teton National Park to survey factors associated with the location of mountaintop and valley-bottom fire-danger-rating stations. Both aerial and ground reconnaissance were made of these areas where possible. Fire-danger-rating problems in Utah and Nevada will be studied during 1955.

Large Log Study

At the Priest River field laboratory studies have been under way since 1942 of the moisture content of large logs. A major purpose of this study has been to determine whether or not the moisture content of heavy fuels indicates critical burning conditions. The results of this study of heavy fuels has been a major factor in development of the Model 7 burning-index meter. The normal seasonal trend of large-log moisture contents follows very closely the actual weather behavior. The effect of a dry May, wet June, late August rain, Indian summer, and fall rains can all be found from the moisture-content curve of large logs. The over-all results of this study will be published in 1955.

Fire-Danger-Rating Instruments

The forest-fire laboratory has been assigned responsibility for carrying out a servicewide project in the development of new and improved fire-danger-rating equipment. The scope of the project is broad. It includes such items as portable fire-danger stations, weekly recording and automatic fire-danger stations, small motor-driven fan psychrometers, and electrical resistance-type fuel-moisture scales.

A nationwide survey is being made of needs and ideas. During 1954 work was started on the development of a fully portable, lightweight instrument shelter, a solenoid-type recording anemometer, and an electrically driven fan psychrometer.

Fuel-moisture-stick manufacturing under the supervision of the forest-fire laboratory was continued at the Spokane Warehouse. All fuel-moisture sticks for the western United States and Alaska are manufactured here. Testing of fuel-moisture sticks for performance characteristics was continued at the Priest River Experimental Forest.

Arrangements were made in 1954 for additional forest protection agencies in the Inland West to take advantage of the instrument calibration and repair service at the forest-fire laboratory. The wind tunnel and other instrument facilities at the laboratory can now serve a much greater area in maintaining high standards for fire-danger-rating systems. This program, financed by the agencies operating fire-danger stations and supervised by fire-laboratory technicians, is an important factor in providing better research data and operational information on fire weather in the Inland West.

LIGHTNING FIRE RESEARCH

Project Skyfire--the broad cooperative program of lightning fire research--completed its second field season. During 1954 several additional agencies joined in various phases of the research program. Highlights of the 1954 field season were the conducting of a cloud survey in the northern Rockies, Oregon, and California; the pioneer operations of the Munitalp-University of Washington-Forest Service mobile atmospheric-research laboratory; and special synoptic analyses of lightning storms and the jet stream.

Cooperative Research

Project Skyfire is aimed at (1) gaining basic information on lightning fires and storms, and (2) testing the possibilities of preventing or reducing the severity of lightning fires through cloud modification. These aims are being accomplished through a cooperative research program. At the end of 1954 there were 15 private, state, and Federal agencies participating in the program, including 3 national forest regions and 2 forest experiment stations.

The Munitalp Foundation, Inc., along with the Forest Service is the primary backer of Project Skyfire. The Foundation's major contributions include financing construction of the mobile atmospheric research laboratory, furnishing of time-lapse motion-picture cameras, film, and film processing, general technical supervision of meteorological phases of the project, and assistance in financing training schools and publications. Mr. Vernon Crudge, Executive Director of The Munitalp Foundation, is assisting in general planning and supervision of the project. Dr. Vincent J. Schaefer, Director of Research for the Foundation is codirector of Project Skyfire. He maintained his field-season headquarters at the Priest River Experimental Forest and assisted in all field phases of the project. Dr. Paul B. MacCready, Jr., Research Associate of the Foundation, assisted at the Forest-Fire Laboratory and at Priest River on many project activities during 1954. Donald Fuquay, of Munitalp and the University of Washington, is the designer and operator of the mobile atmospheric laboratory.

The U. S. Weather Bureau is assisting in many phases of the project including special synoptic analyses, the furnishing of jet stream and other weather maps, special forecasting, and assistance in general analyses of cloud-survey data. The fire-weather office at Missoula, under the direction of W. R. Krumm, is one of the main nerve centers of the project where cloud-survey information is received daily by radio from the Skyfire network of fire lookout stations. The fire-weather forecasters at Missoula and Pendleton, Oregon, prepare special reviews of lightning-storm periods. General assistance on the California cloud survey was given by the Western Fire-Weather Coordinator at San Bruno, California. During 1954 the Chief of the Weather Bureau assigned Mr. Kenneth Nagler, Research Meteorologist, to assist in special synoptic analyses of lightning storms and the jet stream.

University of Washington.--The Department of Meteorology and Climatology has assisted in the designing, construction, and operation of the mobile atmospheric-research laboratory. The laboratory has now become a full-time project for Meteorologist Donald Fuquay.

Montana State University.--Mr. Donald Drummond of the School of Forestry assisted Project Skyfire throughout the 1954 field season in the training and inspection of personnel at cloud-survey stations.

The University of Idaho has constructed a cloud chamber for studies of atmospheric nuclei.

The Boeing Airplane Company is assisting with unique, high-altitude photography of clouds and lightning storms.

The General Electric Research Laboratory is furnishing instruments and special technical assistance. Dr. Irving Langmuir assisted in the initial field activities and is a technical advisor to Project Skyfire. Mr. Raymond Falconer is experimenting with special long-range forecasts for part of the project area.

The National Park Service is operating Skyfire cloud-survey stations at Yellowstone and Yosemite and is assisting in providing data on lightning fires.

The California State Division of Forestry is operating experimental cloud-survey stations in California.

The California Forest and Range Experiment Station assisted in planning the California cloud-survey network and in training personnel.

Forest Service Regions 1, 5, and 6 are operating cloud-survey stations. In Regions 1 and 6 a radio network is used to transmit daily cloud and lightning data to the Forest-Fire Laboratory at Missoula.

Cloud Survey

During the 1954 fire season a cloud survey was conducted from 17 forest-fire lookout stations in northwestern Wyoming, western Montana, northern Idaho, and northeastern Oregon. Later in the fire season eight stations were added in California. The purpose of the survey is to chart the development, movement, and action of clouds and lightning storms. This information is expected to assist in providing a better understanding of the life cycle of lightning storms. It is also providing information on general fire weather and fire behavior. Time-lapse motion-picture cameras were again operated at key stations.

Prior to the 1954 fire season a cloud-survey manual was prepared as a guide for personnel at fire-lookout stations. This manual proved very helpful in identifying and measuring clouds and in observing lightning storms. It is planned to revise and print the manual in 1955.

The 1954 Project Skyfire training school held at the Priest River Experimental Forest was attended by 25 lookout observers. The experience in conducting schools of this type indicates that fire-lookout personnel can be instructed in a relatively short period to identify and measure clouds and to record vital information on lightning. These techniques are expected to become important factors in the operation of future fire-lookout systems in lightning areas.

Analysis of the 1954 cloud-survey data has only begun, but it is now known that several significant factors have been developed. Perhaps the most important is the development of a workable cloud-survey technique. Other significant results include the development of new methods for measuring cloud heights and speeds. Research Paper No. 35 prepared in November 1954 summarizes the cloud survey and general Skyfire results to date.

Mobile Atmospheric-Research Laboratory

The first field operations of the mobile atmospheric-research laboratory were made in 1954. The laboratory as now equipped can measure

and record such factors as wind velocity and direction, dew point, temperature, incoming and outgoing radiation, salt particle content of atmosphere, condensation nuclei, ice-forming nuclei, sky brightness, and atmospheric electricity. Field tests of ability to measure these factors were made at several valley-bottom and mountaintop locations. As a result of these tests a few minor revisions and improvements will now be made. The tests show that the laboratory is an excellent unit which will permit pioneer studies to be made of many important phases of the lightning-fire problem. The mobile laboratory demonstrated its over-all usefulness in forest-fire research when its instruments measured and recorded heat and weather factors during the experimental burning of logging slash at the Priest River Experimental Forest.

During 1955 the mobile laboratory will be used to record atmospheric factors in lightning-storm areas. The laboratory will operate at key mountaintop locations during much of the 1955 fire season. If possible, the laboratory will be used in studies of micrometeorological factors on going fires.

LOGGING SLASH RESEARCH

The Priest River Field Laboratory

The cooperative University of Idaho-Forest Service logging-slash research project has been under way for almost 3 years. Forest Service efforts have centered at the Priest River Field Laboratory. To date 161 plots have been burned experimentally, containing 3 weights per acre of slash of the Region's 9 commercially important species. The plots burned in 1954 were immediately recharged with slash for burning in August, 1955. At that time burning experiments will have been completed on current year's and 1-year-old slash of all 9 species. After being recharged in 1955, the plots will be held for burning after the slash has aged for 5 years.

Experimental burning has yielded valuable new information on the behavior and heat of slash fires. In 1954 the University of Washington, Department of Meteorology and Climatology, assisted in the Priest River slash-burning program by providing instruments and technical advice in measuring heat radiation. This valuable cooperation is expected to continue. In addition to experimental burning, initial research has been completed on moisture content and rate of drying of freshly cut slash, and on amount of slash contained in tree crowns in relation to species and size of tree. The tree-crown study has been carried out in cooperation with the California Forest and Range Experiment Station. The following is a general summary of the results to date:

Rate of Spread of Slash Fires

The effect of quantity.--The amount of slash present, measured in terms of tons per acre, is the major factor affecting rate of spread

in the current year's slash. As slash ages, weight per acre remains a major factor, but becomes relatively less important.

The effect of species.--In current year's slash, species has a negligible effect on rate of spread in moderately to very heavy slash concentrations. In light concentrations of slash of species which lose their needles in drying, however--e.g., western hemlock and Engelmann spruce--fire will spread hardly at all. Species becomes a more important factor as slash ages because the quantity of fine fuel is reduced at different rates in different species.

The effect of age.--Aging for 1 year reduces rate of spread in most species of slash. So far the least apparent reduction--practically none--has occurred in white pine slash; the greatest in Douglas-fir slash. The main cause of change in rate of spread is loss of needles by some species. Compaction is a secondary cause which is relatively unimportant the first year. Heavy concentrations of species which lose their needles immediately after cutting or which do not lose them within the first year burn just about as fast and hard as when they were first laid out. Some reduction occurs in rate of spread in light to medium concentrations.

The effect of rising humidity.--An increase in humidity quickly reduces rate of spread in light and medium slash concentrations. Rate of spread in heavy concentrations is not affected significantly within 1½ to 2 hours after humidity begins to increase.

Quantity Measurement of Slash

Calculation of weight per tree.--Ovendry weight of a tree crown can be expressed mathematically, and hence graphically, as a function of d.b.h. and length of crown. For a single tree the calculation of ovendry weight may be very appreciably in error; but for the area of a timber sale, for example, the calculated total weight of slash which would result from cutting the stand should be sufficiently accurate to support an area flammability rating and to serve as the basis for a slash-disposal plan. In young merchantable and mature stands, amount of slash per tree of a given size is roughly proportional to the tolerance of the species: the more tolerant, the more slash. This picture may be less true in overmature stands since some intolerant species, notably ponderosa pine, develop large branches containing a disproportionate amount of wood.

Moisture Content of Slash

The starting point.--Freshly cut branches and fine twigs usually have a moisture content of 100 to 150 percent. The moisture content of larger branches and the trunk is reduced in proportion to the amount of heartwood present. The moisture content of heartwood may be as low as 30 percent.

Drying of fine material.--Needles and fine twigs on lopped branches fully exposed to the sun dry to 10 to 12 percent moisture content in about 2 weeks of midsummer weather; those in partial shade, in 3 weeks; those in full shade (south slope) in 4 weeks. Much more time is required if the branches are attached to the trunk of a large top. Those in full sunlight or half-shade dry to 12 percent in about 6 weeks, while those in full shade still contain between 95 and 100 percent moisture at the end of 3 months.

Drying of heavy material.--The trunk of a large top begins to dry as soon as it is cut. Moisture from the sapwood goes both into the air and into the drier heartwood. At the end of 5 to 6 weeks moisture content is approximately uniform throughout the piece. Heavy material in the sun or partial shade dries to about 30 percent moisture content in 3 months; in full shade, to about 40 percent. Normal warm-season precipitation during this initial drying period has no discernible effect on decline in moisture content.

Slash-Disposal Methods

Chipping.--Rate-of-spread tests showed that chipping slash reduced flammability to the point where the chipped material would burn actively only during the early afternoon of a dry, hot day. While experimental chipping was very costly, experience elsewhere indicates that this method of slash disposal may prove to have utility in special situations in the northern Rocky Mountains.

Roofing slash piles.--Covering hand-made slash piles with building paper was found to save 1 or 2 cents a pile in burning costs, over and above the cost of the paper. A greater advantage of roofing should be improved ability to schedule burning and to burn when fires cannot spread. Roofed piles ignite readily and burn out well in very wet weather.

FOREST ECONOMICS RESEARCH

The new surge of industrial and economic development occurring in the Rocky Mountains from Canada to Mexico places greater emphasis on the work of the Division of Economics. We have both a big Forest Survey task ahead and an important responsibility for economic studies.

FOREST SURVEY

Although the job of inventorying the forests of the United States was begun about 1930, major emphasis of the survey in the past has been in other parts of the country. Only in North Idaho and western Montana in the Rocky Mountain region was the timber industry development sufficient to justify surveys in the 1930's. As a consequence, although 75 percent of the forest area in the United States has now been covered at least once by the Forest Survey, only 31 percent of the forests in the eight Rocky Mountain states has been inventoried. Montana has been completely covered. It is hoped that the timber inventory of South Idaho will be finished in 1955 to complete that state also. But nothing has been done in Wyoming, Colorado, Arizona, New Mexico, Utah, or Nevada. As a matter of fact, these six states constitute the one major block of unsurveyed forests in the continental United States. Two factors make it important to complete the survey in these states before many more years have elapsed. One is the growing interest of the timber industries in the commercial forests of these states. The other is that in the absence of survey data the six states are a soft spot in the Nation's timber inventory knowledge.

In 1954 about 3 percent of the uninventoried area in the eight Rocky Mountain states was covered by the Forest Survey. Field work was completed on approximately 2.3 million acres of forest land in Bonneville, Butte, Custer, Fremont, and Lemhi Counties in Idaho. This brings the total surveyed area south of the Salmon River in Idaho to 9.1 million acres. Approximately 1.7 million acres more are yet to be inventoried there. When this area has been inventoried a comprehensive statistical report for South Idaho and analytical report for the entire state will be prepared. Historical and other material are now being assembled for the report.

We plan to move into Wyoming during the coming year and also lay out detailed plans for the Forest Survey in the rest of the Rocky Mountain area.

In an effort to speed up office work we now use a punch card system exclusively for compiling areas and volumes. We are also studying ways and means for streamlining field work. In cooperation with the Washington office of the Forest Service and the California Forest and Range Experiment Station, a study of field techniques for type mapping

and area determination was instituted several years ago. Comparisons and tests of ground mapping and aerial photo delineations of timber types will provide information on the relative costs and accuracy of the two methods.

As part of this same effort to develop better inventory procedures an expert photogrammetrist, Karl E. Moessner, was added to the staff to assist Forest Survey personnel in the use of aerial photographs and to carry out research in this important field. He was formerly associated with the Central States Forest Experiment Station at Columbus, Ohio. He has begun studies relative to problems in aerial photo interpretation techniques. Among other things these studies will attempt to determine whether techniques of stand measurement, dot sampling, and aerial estimating now being used in the eastern United States are feasible for surveys in the Rocky Mountain area. It is expected that the services of this photogrammetrist will not only improve the efficiency of the Forest Survey but also result in more and better use of aerial photographs by national-forest administrators and land managers in general.

While pushing forward with the initial survey in the 6 states, we are conducting reinventory or maintenance surveys in those areas covered some years ago. A reinventory of North Idaho was completed several years ago. A maintenance survey is now in process in western Montana. Approximately 1 million acres of forest land in Lincoln, Mineral, and Sanders Counties were covered during 1954, bringing the total resurveyed area in Montana to 2.6 million acres. It is hoped that the reinventory of these three counties will be completed in 1955.

In connection with its Forest Survey activities the Division of Economics has conducted periodic canvasses of the timber cut for various products. In 1954 the only major project of that sort was a survey of pole production in 1953 conducted in cooperation with the Rocky Mountain Pole and Treating Association. This pole production information will be published early in 1955. The canvass showed that in 1953 approximately 414,000 poles were produced in the Northern Rocky Mountain region which consists of northeastern Washington, North Idaho, and Montana. The proportions of poles cut by species were as follows:

Western redcedar	46.3 percent
Lodgepole pine	31.1 "
Western larch	21.8 "
Douglas-fir	.8 "

The total output declined from 1952, although lodgepole pine pole production increased.

ECONOMIC STUDIES

Prior to consolidation the Northern Rocky Mountain Station and the Intermountain Station each had one man engaged in economic studies. In the former he was concerned primarily with forest economics problems, and in the latter with rangeland problems. We feel the combining of these two undermanned activities will lead to a considerably stronger program than has been possible in the past. As a first step toward developing a well balanced program we have been engaged in a reappraisal of the economics problems relating to wild land management and development. Forest Service administrative personnel of the Intermountain region were contacted to get their ideas on needs for economics research. Their response was excellent and these suggestions were added to those made by personnel of the Northern Rocky Mountain region in 1952. These suggestions are being studied in the light of our finances and capacities, and actual studies will be started in 1955.

In 1953 the Station published Research Paper No. 31 to provide up-to-date facts on the location, extent, and use of the wild land resources in the Intermountain region. The supply of this paper is now exhausted so a completely revised edition, adding a section on statistics for the Northern Rocky Mountain region, was prepared by J. O. Lammi. It will be published early in 1955.

In cooperation with other agencies and individuals, and under the general sponsorship of the Montana Conservation Council, this Station helped conduct the 1954 Montana Conservation Caravan. This Caravan is a 1-week bus trip by teachers, bankers, farmers, legislators, and others interested in conservation through a portion of the state for the purpose of studying the natural resources. S. Blair Hutchison of this division was chairman of the Caravan, and George R. Fahnestock of the Fire Research Division carried much of the responsibility for developing a Caravan guide book. The principal interest of the Station was in this guide book. There has been a particular need to develop more effective tools for teaching natural resources conservation in both grade and high schools. Therefore the guide book, "Natural Resources--A tour in western Montana," represents an experiment in the presentation of resources material for teaching purposes. The Montana Conservation Council has made 500 copies available to the schools in the state, where it is being tested.

RELATED PROJECTS

At the request of the Foreign Operations Administration of the State Department, and at their expense, Harry W. Camp made a trip to Iran the latter part of the year for the purpose of helping that country organize a survey of its 7 million or so acres of forest along the Caspian Sea. His assignment, which started in November, will extend through February 1955.

During 1954 the Experiment Station completed its collection and compilation of forest statistics in connection with the Forest Service's Nation-wide Timber Resource Review. In addition the Division furnished one man to the Washington office for part of the year. He was engaged in analysis of the long-range timber outlook in the United States as a whole.

FOREST UTILIZATION SERVICE

Each year sees an increasing volume of forest products flowing from the Intermountain area into the Nation's wood-using markets. Lumber is the principal commodity but veneer, plywood, mining timbers, pulpwood, poles, piling, and other products, are on the increase. Numerous new sawmills and other wood-processing plants were built during the past year with the biggest developments taking place in Montana. New plywood, veneer, pulp, chipboard, and pulp chipping capacity was also added to the area during the past year. This upsurge in sawmilling capacity has increased the need for research in two of the Region's basic utilization problems, profitable use of tremendous volumes of wood residues at sawmills, and substitution for ponderosa and white pine of species such as lodgepole pine, mountain Douglas-fir, Engelmann spruce, cottonwood, aspen, and alpine fir. This will alleviate overcutting of these two valuable pines.

Most of the Intermountain forests were overripe when lumbering started and harvest has not progressed fast enough to forestall catastrophic insect damage. Billions of feet of virgin lodgepole pine and Engelmann spruce have died. To allow this material to go unused will deprive the regional industries of 60,000 man-years of payrolls. Research is needed on improved mechanized methods of harvest and on industrial uses for this vast woodpile.

UTILIZATION OF BEETLE-DAMAGED SPRUCE

Field work for the last of a series of Engelmann spruce depreciation studies carried on during the past two years was completed in October at the J. Neils Lumber Company mill in Libby, Montana. The objective of these milling studies was to determine elapsed time between infestation of the trees by beetles and profitable salvage for lumber.

Spruce logged in August 1953, from 1952 beetle-struck dead trees, dry-decked at Libby over winter and milled July 3, 1954, showed about the same deterioration as spruce logged in August 1954 from 1952 beetle-struck dead trees decked at Libby and milled October 2, 1954. Fall-down in value because of shrinkage and grade depreciation due to bug defects amounted to 20.7 percent. Of this figure, 3.2 percent was due to shrinkage. It was concluded that 2-year-old beetle-struck dead trees still produce good lumber with a profit margin. However, since the summers of 1953 and 1954 had no extremely hot weather and frequent rains were the rule, depreciation from checking was perhaps unduly retarded.

Foresters are hoping for moderate summer temperatures and frequent rains in 1955, such as occurred during 1954, to make possible salvage

of material that might otherwise not be suitable for lumber. Bug-killed spruce will in many instances be suitable for pulp and paper production for about 15 years.

POLES AND POSTS

Strength tests of three Intermountain species suitable for transmission poles--western larch, western redcedar, and lodgepole pine--were started during the year at the Forest Products Laboratory under a cooperative program with the American Society for Testing Materials. The over-all A.S.T.M. program at the Laboratory also includes testing two other pole species, Douglas-fir and southern pine. There are three separate phases to the project. In phase 1, green short-leaf pine poles will be tested to determine the correlation between crib and machine testing. In phase 2, all species will be tested green to determine the correlation between the strength of green poles and the strength of small, clear specimens of wood. In phase 3, treated poles will be tested similarly.

Green western larch poles were tested last spring. Strength properties of full-sized poles were well correlated with strength figures obtained by testing small, clear specimens of the wood. Average strength property for this sample of western larch was equal to results of any previous tests made to date.

Spiral Grain in Transmission Poles

Western larch transmission poles with extreme left-hand twist or spiral grain show distortion of as much as 50 degrees. These transmission poles, installed the summer of 1952, are being observed at the Newport Pole Farm of the Inland Empire Research Center. Since the poles were installed in 1952, they should be at least reasonably well seasoned at this time. Recent observations indicate that poles with left twist, particularly those having an extreme left twist, are still the bad actors. (Extreme twist has been defined as that spiral having a departure of more than 1 inch in a longitudinal distance of 1 foot of pole.) The poles continue to twist in the direction of the spiral during the summer and untwist to some extent during the moister winter months.

Considerable confusion has resulted from the use of the terms "clockwise" and "counterclockwise" twist or spiral. These terms have been discarded and reference will be made in the future to spiral as "slopes to left (or right) upward" as observed from the foot of a pole or tree. It is planned to continue this study for a number of years to ascertain whether seasoning or aging of the pole has a stabilizing effect on the twist. It is also planned to conduct a post-mortem of poles to determine interior structural characteristics that might be related to left- or right-hand twisting.

Service Life of Lodgepole Pine Fence Posts

One of the earliest experiments testing the value of the chlorine and phenol combinations as a wood preservative was established at the Squaw Creek Ranger Station of the Gallatin National Forest near Bozeman, Montana, about 19 years ago. Reconstruction of the West Gallatin highway has necessitated removal of almost half the test posts. After 19 years of service they are in excellent condition. The treating solution consisted of tetrachlorophenol and gas oil. The computed solution strength was 3.22 percent tetrachlorophenol. This preservative, originally known as Dowicide 6, contained approximately 90 percent tetrachlorophenol and the rest of the soluble portion consisted of other chlorinated phenols, such as trichlorophenol and possibly some pentachlorophenol. It is hoped that this service test can be continued for at least 20 more years.

INDUSTRIAL DEVELOPMENTS

New Plywood Plant at Polson, Montana

The Polson Plywood Company, Inc., the third new plywood plant constructed in the Intermountain area in recent years expects to be in production within the next few months, producing 15 million square feet of plywood annually. This operation started about 4 years ago with a slicing operation at the Polson Lumber Company producing edge-grain pattern veneer from western larch flitches. The principal species used for rotary-cut veneer will be western larch, with smaller amounts of ponderosa pine. Sliced veneer will be produced from Engelmann spruce, ponderosa pine, and western white pine, and will be used for the knotty pattern of paneling. Exploratory work on all these species has been done by the Madison Laboratory. The Forest Utilization Service has been working with the Polson group since the inception of the plywood plant idea back in 1944.

Pulp Chips From Sawmill Residue

As the first unit of a hardboard plant being promoted at Missoula, the chip preparation plant has gone into production. It is equipped with a Diamond hog, operated by a 60-horsepower motor. The present total electrical requirement of the plant is about 175 horsepower. The plant has a capacity of about 50 units of chips (200 cu.ft. per unit) per 8-hour shift or about two carloads.

All softwood species common to this area except western redcedar are used, but no bark is tolerated. Raw material consists mainly of trimmer ends, about half of them being kiln-dried and the other half unseasoned. Cost of the raw material ranges from $2.25 to $3.00 per unit. Since the chips are being used in the sulphate process, chip specifications are rather liberal. Fines are screened out on a ¼-inch

mesh and anything is taken that will go through a 1½-inch mesh. Chips are being purchased by the Potlatch Forests Pulp and Paper Mill at Lewiston, Idaho.

An extensive survey by the Forest Utilization Service indicates over 2,000 cords of chip material are available daily at railhead in the Intermountain area.

PUBLICATIONS

A. Departmental publications

HUTCHINGS, SELAR S. Managing winter sheep ranges. U. S. Dept. Agr. Farmers' Bull. 2067, 46 pp., illus. 1954.

Descriptions of methods of good management, including knowledge of forage plants, recognition of range condition, and practice of moderate and uniform grazing; economic benefits of good management; important forage plants.

PECHANEC, JOSEPH F., GEORGE STEWART, and JAMES P. BLAISDELL. Sagebrush burning--good and bad. U. S. Dept. Agr. Farmers' Bull. 1948, rev., 34 pp., illus. 1954.

Where, when, and how to burn sagebrush for range improvement; costs of burning; and range management practices needed to maximize benefits of burning. A revised, up-to-date edition of U. S. Dept. Agr. Farmers' Bull. 1948 published in 1944.

PECHANEC, JOSEPH F., GEORGE STEWART, A. PERRY PLUMMER, JOSEPH H. ROBERTSON, and A. C. HULL, Jr. Controlling sagebrush on rangelands. U. S. Dept. Agr. Farmers' Bull. 2072, 36 pp., illus. 1954.

Methods of controlling sagebrush including burning, plowing, railing, harrowing, beating, grubbing, and spraying, on various kinds of range; where and when to control sagebrush; and range management practices to use after sagebrush is removed.

B. Publications in scientific and professional journals, etc.

ANDERSON, I. V. Suitability of Rocky Mountain woods for veneer and plywood. Jour. Forestry 52(8): 587-591. 1954.

Volume available for plywood and suitability of western larch, ponderosa pine, Engelmann spruce, western (Idaho) white pine, mountain Douglas-fir, cottonwood, aspen, and white birch.

BAILEY, REED W., and G. W. CRADDOCK. Contributions of western public lands to conservation. Jour. Soil and Water Conservation 9(2): 59-64. 1954.

Birth of conservation stemmed from action taken on western public lands, including development of concepts of conservation with use, sustained yield, and multiple resource use; describes contributions of western lands to professional status of conservation.

BARROWS, J. S. Lightning fire research in the Rocky Mountains. Jour. Forestry 52(11): 845-847. 1954.

Summary of the objectives, organization, and first field activities of Project Skyfire: the lightning fire problem in the Rockies and a broad research program.

BARROWS, J. S. Project Skyfire. Proceedings Western Forestry and Conservation Assn., 45th Annual Forestry Conf., San Francisco, Calif., Dec. 1954.

Progress report on lightning fire research in western forests including a summary of the cloud survey in the northern Rockies, Oregon, and California, and of the mobile atmospheric research laboratory.

BLEAK, ALVIN T., and A. PERRY PLUMMER. Grazing crested wheatgrass by sheep. Jour. Range Mangt. 7(2): 63-68. 1954.

After 7 years' spring utilization of 88 percent, damage to grass was obvious, and Russian-thistle had increased markedly, in comparison with pastures grazed to 71 and 59 percent. Sheep days' use declined in all pastures, but most in the heavily grazed pastures, and in general differences in animal production paralleled trends in vegetation.

BOE, KENNETH N. Periodicity of cone crops for five Montana conifers. Proc. Mont. Acad. Sciences 14: 5-9. 1954.

An analysis of a 22-year record of cone crop observations made by the U. S. Forest Service, describing periodicity characteristics and seed production potential by geographic areas.

CRADDOCK, GEORGE W. Water yield from snow as affected by consumptive losses. Proc. Joint Meeting Western Snow Conference and Colorado River Basin Water Forecast Committee. 1954.

Decreasing forest and range plant cover increases sediment production and flood discharges more than annual water yields. Comparison of relative efficiency of four kinds of range plants in utilizing precipitation for herbage production, and precipitation available for runoff.

CURTIS, JAMES D. and DAVID TACKLE. Pulpwood moves east from the Targhee. The Timberman 55(9): 122-123. 1954.

An operation clear cutting lodgepole pine for pulpwood in southeastern Idaho, and the silvicultural implications of this kind of cutting in the lodgepole pine type.

ELLISON, LINCOLN. Subalpine vegetation of the Wasatch Plateau, Utah. Ecological Monographs 24(2): 89-184. 1954.

Presentation of salient characteristics of soil development and primary succession, and reconstruction of character of original herbaceous vegetation, both of which differ markedly from traditional concepts; and description of changes in soil and vegetation under livestock grazing.

ELLISON, LINCOLN, and J. E. COALDRAKE. Soil mantle movement in relation to forest clearing in southeastern Queensland. Ecology 35(3): 380-388. 1954.

Although landslides are common under sown pasture, on equally steep slopes under rainforest soil mantle movement is also very rapid, but less conspicuous. It is not known under which type of cover greater total displacement occurs.

EVANKO, ANTHONY B. Forage species for reseeding northeastern Washington rangeland. Northwest Science 28(2): 70-76. 1954.

Preliminary results of species adaptation and season of seeding tests on submarginal cropland at three locations.

EVANKO, TONY. State Cattleman "Dutch" Bremner gets help through Curlew District, Wash. State Conservation Districts News 3(1): 7. Jan. 1954.

Through artificial revegetation and improved management, production of forage on submarginal cropland has been increased many fold, relieving grazing pressure on native ranges.

EVANKO, TONY, and JOHN ARMSTRONG. Reseeding the range. Washington Farmer 79(3): 5. Feb. 9, 1954.

Results of forage species adaptation and methods tests at three locations in northeastern Washington.

FAHNESTOCK, GEORGE R. Roofing slash piles can save--or lose--you dollars. Fire Control Notes 15(3): 22-26. 1954.

Slash piles covered by 4' x 4' building-paper roofs were burned during extremely wet fall weather on the same day as unroofed piles. It was found that 70 percent more roofed than unroofed piles could be burned in a given period. Main advantage of the practice is that slash can be burned cheaply when there is no chance for fire to spread.

HARDY, CHAS. E. Sticks measure fire danger. Western Conservation Journal 11(1): 16-17, 28-30, illus. 1954.

Describes manufacturing use of sets of 1/2-inch wood cylinders in the measurement of forest-fire danger.

HELMERS, AUSTIN E. Precipitation measurements on wind-swept slopes. Trans. Amer. Geophys. Union 35(3): 471-474. 1954.

Measurements from standard and three modified 8-inch rain gages on 22° slope in Priest River Experimental Forest over 3 years. The three modifications are: (a) standard with horizontally mounted Alter windshield; (b) orofice cut to angle parallel to slope with no windshield; and (c) sloped orofice with windshield parallel to slope. Catch from the last agreed well with snow pack water equivalent measurements.

JOHNSON, PHILIP C. A feeding record of the ten-lined June beetle. Jour. Econ. Ent. 47(4): 717-718. 1954.

An unusual record of feeding on ponderosa pine foliage near Spokane, Washington by adults of the ten-lined June beetle, Polyphylla 10-lineata (Say).

JOHNSON, PHILIP C. A hibernation record of Ips plastographus Leconte (Coleoptera: Scolytidae). Canadian Ent. 86(9): 431-432. 1954.

An instance of the California pine engraver (Ips plastographus Lec.) hibernating in short tunnels in the sapwood of host trees was noted by the author in Montana. While it is known that some species of Ips overwinter as new adults in trees other than the larval hosts, the present record is believed to be unique.

HUTCHISON, S. BLAIR. Fitting big dams into little economies. Land Economics 30(4): 329-332. 1954.

The impact of large dams on local communities, with particular reference to the proposed Libby Dam on the Kootenai River in Montana. Proposes that impact costs be given the same consideration as installation costs in planning dam projects.

LAMMI, J. O. Review of "Economics of Agricultural Production and Resource Use," by Earl O. Heady. Jour. Range Mangt. 7(5): 228. 1954.

SQUILLACE, A. E., and R. T. BINGHAM. Breeding for improved growth rate and timber quality in western white pine. Jour. Forestry 52(9): 656-661. 1954.

Techniques and early results of intraspecies breeding for faster growth rates and better quality in western white pine. Progeny seedlings produced through controlled pollinations among selected trees varied considerably in total height and significantly, though not strongly, reflected the growth rate of their respective parents. Average annual height growth during the last 10 years appeared better for studying heritability than average annual height growth during the whole life of the parent trees. A technique for measuring phenotypic traits in relatively open-grown, young western white pine trees was devised which proved practical.

SQUILLACE, A. E., and R. T. BINGHAM. Forest genetics research in the northern Rocky Mountain region. Jour. Forestry 52(9): 691-692. 1954.

Brief descriptions of forest genetics research projects in the northern Rocky Mountain region and some tentative recommendations for the conduct of future research.

TACKLE, DAVID. Comments on the Baker automatic tree seed planter. Jour. Forestry 52(7): 530-531. 1954.

Conclusions drawn from field trials of the Baker planter, using ponderosa pine, Jeffrey pine, and lodgepole pine seed.

C. Miscellaneous processed reports

BARROWS, J. S., VINCENT J. SCHAEFER, and PAUL B. MacCREADY, Jr., Project Skyfire--A progress report on lightning fire and atmospheric research. Intermount. Forest and Range Expt. Sta. Research Paper 35, 49 pp., illus. 1954.

The lightning fire problem in the West and organization of a broad cooperative research project, giving initial results of the cloud survey and jet-stream study and a chapter on meteorological approaches to reduction of fire danger.

DENTON, ROBERT E. Midge damage affects Christmas-tree production in the Inland Empire. Intermount. Forest and Range Expt. Sta. Research Note 7, 4 pp., illus. 1954.

A tiny midge, previously not recorded on Douglas-fir, threatens the Christmas-tree industry in northeastern Washington, northern Idaho, and northwestern Montana. Referred to locally as the Douglas-fir needle midge, Cecidomyia sp., the insect spends its early life feeding on juice within the needles. Damage during 1953 is estimated to have cost the Christmas-tree industry over 1 million dollars.

HOLMGREN, RALPH C. Progress report for 1953. (Cooperative research program for revegetating the deer winter ranges on the Payette and Boise River Drainages, Intermountain Forest and Range Expt. Sta., Idaho State Fish & Game Department, and Boise National Forest, cooperating.) Mimeo., 12 pp., 1954.

Status of our knowledge regarding game winter range revegetation; recommendations for planting in the granitic foothill areas of southwestern Idaho; problems needing further study.

HOLMGREN, RALPH C. A comparison of browse species for revegetation of big-game winter ranges in southwestern Idaho. Intermount. Forest and Range Expt. Sta. Research Paper 33, 12 pp. 1954.

A test of 24 species. The 12 that survived are rated on seed characteristics, palatability to game, growth rate, height at maturity, and damage by grasshoppers and gophers. Bitterbrush appeared most promising.

HOUSTON, WALTER R. A condition guide for the aspen ranges of the Intermountain region. Intermount. Forest and Range Expt. Sta. Research Paper 32, 21 pp., illus. 1954.

Ratings in five condition classes based upon species composition and production of aspen understory vegetation and adjacent vegetation in openings, percent ground cover, and accelerated erosion.

HUTCHISON, S. BLAIR, GEORGE R. FAHNESTOCK, et al. Natural resources, a tour in western Montana. Montana Conservation Council, 78 pp., illus. 1954.

Natural resources of Montana and their management. Written as a guide to the 1954 Conservation Caravan, an annual trip sponsored by the Montana Conservation Council, and intended to be an aid to the teaching of conservation.

HUTTON, GORDON A. Montana Christmas tree shipments again hit 3-million mark in 1953. North. Rocky Mountain Forest and Range Expt. Sta. Research Note 137, 3 pp. 1954.

Numbers of Christmas trees shipped from various Montana counties by rail and by truck, and numbers shipped to various states in 1952 and 1953.

JOHNSON, PHILIP C. Logging damage affects bark beetle resistance of residual ponderosa pine stands. Intermount. Forest and Range Expt. Sta. Research Note 6, 4 pp., illus. 1954.

During sanitation-salvage logging in western Montana trees of high insect risk were cut leaving 66 percent (9,990 board feet per acre) of the original pine stand. During various operations, but mainly that of skidding, 6.2 percent (617 board feet per acre) of the residual stand was damaged in varying degrees. Extra care in logging is urged wherever beetle protection is a major objective.

LAMMI, J. O. Primary money income from range watersheds. Ph. D. Dissertation, University of California, Berkeley. Jan. 1954.

Two ways of measuring money income from range-watersheds are developed by use of national income accounting principles. The two measures are then compared in some range-watershed management situations in Utah to determine their probable usefulness as economic guides to managers of public lands.

LAMMI, J. O. Northern Rocky Mountain pole production in 1953. Intermount. Forest and Range Expt. Sta. Research Note 13, 3 pp. 1954.

Results of pole production survey by species, number, percent of total, and state of origin; numbers of poles by species by years, 1947 to 1953; percentages by length and A.S.A. class for each species.

LYNCH, DONALD W. Growth of young ponderosa pine stands in the Inland Empire. Intermount. Forest and Range Expt. Sta. Research Paper 36, 16 pp. 1954.

Tables based on age and diameter showing future 10-year cubic-foot volume growth for individual trees with correcting factors for mortality and converting factors for cordwood and board-foot volumes.

LYNCH DONALD W. What is an acceptable allowable error and sample size in sample log scaling and tree measuring? Intermount. Forest and Range Expt. Sta. Research Note 14, 5 pp. 1954.

A graph alinement chart based on total sale value, variability of volumes, and scaling costs, giving the appropriate sampling error in sample log scaling or tree measuring to meet the point of diminishing returns.

ORR, LESLIE W. The 1953 pine butterfly outbreak in southern Idaho and plans for its control in 1954. Intermount. Forest and Range Expt. Sta. Misc. Pub. 1, 12 pp., illus. 1954.

History, location, extent, type of damage, and plans for controlling an infestation of the pine butterfly, Neophasia menapia (F. & F.), which in 1953 occurred on 169,000 acres of ponderosa pine forest on the Boise National Forest. Identifying characteristics and habits of the adult, egg, larval, and pupal stages are described and illustrated.

PETERSEN, DAN LLOYD. Reinventory of surface soil and plant characteristics, Morris watershed. M.S. Thesis, Botany Dept., University of Utah, Salt Lake City, Utah (in cooperation with Intermountain Forest and Range Experiment Station). June 1954.

Changes in vegetation and soil between 1939 and 1953 on a nonflood-producing subbasin of Farmington Creek, Davis County Experimental Watershed. Plant and litter cover increased on previously lightly grazed lower portion of watershed, but only litter increased on previously heavily grazed headwater portion.

SCHMAUTZ, JACK E. Grass--Cafeteria style in southwestern Montana. Intermount. Forest and Range Expt. Sta. Research Note 12, 4 pp. 1954.

Preferences of cattle for 13 seeded and 2 native grass species on summer range. The natives were grazed lightly when several introduced species were grazed very heavily.

SQUILLACE, A. E. Engelmann spruce seed dispersal into a clear-cut area. Intermount. Forest and Range Expt. Sta. Research Note 11, 4 pp., illus. 1954.

During a bumper seed year sufficient Engelmann spruce seeds were dispersed as far as 9 chains from the timber edge to provide for adequate regeneration, but in fair or poor seed years seed fall at that distance may not be sufficient. Results suggest that about 20 chains should be considered the maximum width in planning the size of clear-cut blocks in Engelmann spruce.

TACKLE, DAVID. Lodgepole pine management in the Intermountain region--a problem analysis. Intermount. Forest and Range Expt. Sta. Misc. Pub. 2, 53 pp., illus. 1954.

A comprehensive analysis of problems inherent to the management of lodgepole pine forests in the Intermountain region. Includes a preliminary classification of lodgepole pine stands, supplemented by photographs and descriptions to aid in recognizing the classes in the field, and a list of suggested studies for a research program.

TACKLE, DAVID. Viability of lodgepole pine seed after natural storage in slash. Intermount. Forest and Range Expt. Sta. Research Note 8, 3 pp. 1954.

Germination tests of seed from unopened cones of all ages collected on the ground and up to 3 feet above ground in 6-year-old logging slash showed that seed from cones above ground had about twice the germinative capacity and germinative energy as seed from cones on the ground.

TERRELL, TOM T. Mortality of the Engelmann spruce beetle brood during the winter of 1953-1954. Intermount. Forest and Range Expt. Sta. Research Note 10, 9 pp., illus. 1954.

An average of 42 percent brood mortality occurred during abnormally low temperatures in January 1954 in western Montana and northern Idaho. Broods below snow level suffered lower mortality than those above snow level. No differences in mortality existed between north and south sides of trees. Evidence suggesting that larvae were more susceptible than adults was inconclusive. Somewhat greater mortality occurred at lower elevations. A predator and a parasite survived better than the host beetle.

WATT, RICHARD F. Mortality in second-growth stands of the western white pine type. Intermount. Forest and Range Expt. Sta. Research Note 9, 5 pp. 1954.

Records collected on 38 permanent sample plots showed mortality to be extremely variable, increasing with volume and age of the stand, and in the case of board-foot mortality, with site index. At 100 years of age, 10 percent of the total board-foot production, 22 percent of the cubic-foot volume, and 30 percent of the basal-area production had been lost through mortality.

WIKSTROM, J. H. Pulpwood production in 1952. North. Rocky Mountain Forest and Range Expt. Sta. Research Note 135, 1 p. 1954.

Results of 1952 survey by species and area of origin, in cords and percent of total pulpwood produced. Areas used in this report are western Montana, eastern Montana, north Idaho, and northeastern Washington.

WIKSTROM, J. H. 1952 log production for lumber and veneer. North. Rocky Mountain Forest and Range Expt. Sta. Research Note 136, 3 pp. 1954.

Log production for lumber and veneer by species, by state and county of origin, in board-foot volumes, and percentages of total production.

WILSON, ALVIN K. Delineating ponderosa pine volume and site quality classes from aerial photographs. Intermount. Forest and Range Expt. Sta. Research Paper 34, 10 pp., illus. 1954.

Suggestions for the use of stereograms in improving timberland sampling, based on experience gained from installing an experiment in ponderosa pine management which required delineating 3-volume-per-acre classes of timber on the ground. Aerial photographs saved considerable time and effort.

WINTERS, WAYNE STREET. Reinventory of soil and plant characteristics of Miller watershed. M.S. Thesis, Botany Dept., University of Utah, Salt Lake City, Utah (in cooperation with Intermountain Forest and Range Experiment Station). June 1954.

Describes changes in vegetation and soil between 1939 and 1953 on a formerly flood-producing subbasin of Farmington Creek, Davis County Experimental Watershed. All vegetation except perennial grasses increased in density. Conifers, aspen, tall shrubs, and shade-loving perennial forbs increased at the expense of low shrubs and grasses. There was an over-all increase in both area and depth of litter.

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* Moved to Missoula, Montana from Coeur d'Alene, Idaho on January 1, 1955.